C.D. Howe Institute
Commentary

ISSN 0824-8001

A Cooler Approach

Tackling Canada's Commitments on Greenhouse Gas Emissions

Daniel Schwanen

In this issue...

A sensible Canadian policy on reducing greenhouse gas emissions would include preparing for the trading of emissions permits and adopting a flexible approach to targets.

The Study in Brief...

Meeting the Kyoto Protocol's emissions-reduction targets for greenhouse gases (GHGs) would be prohibitively costly for both Canada and the global economy. And Canada by itself cannot make a significant difference to rising worldwide emissions and the threat of global warming that many scientists warn results from them. Canada should prepare for a future in which GHG emissions are reduced through binding policies. But it should also ensure that reductions are made in the least costly way possible and that Canadians are not burdened with more than their share while other countries make little or no such effort. Since Kyoto offers no such assurances, Canada needs to consider alternative scenarios.

This paper envisages one voluntary scheme, under which an independent authority would initially allocate low-cost, tradable permits to large Canadian emitters of GHGs on the basis of their emissions in a given base year. The number of permits available each year would be increased, proportional to any increased emissions by Canada's trading partners. If Canada ratified the Kyoto Protocol or a similar agreement, the emissions allowed by these permits would have to be reduced at a slightly faster pace than required by Canada's overall commitments, provided other countries also met their commitments. Allowable emissions could also increase through the acquisition of credits created by reductions abroad, as permitted by various Kyoto mechanisms.

To encourage emitters to participate, governments would undertake to recognize the permits acquired under the voluntary scheme in the event that binding reduction measures were later introduced. Credits that could be exchanged on the permits market could also go to the numerous smaller emitters or any other nonparticipant in the permit system for projects that led to verifiable emissions reductions.

Such a system would prepare Canada better than the purely voluntary approach followed so far, and it would reduce emissions more efficiently than through the use of new economy-wide standards. And it would be easier to implement and politically more feasible than a carbon tax, especially given governments' commitments that no region of Canada would be unduly affected. Finally, it would also complement appropriate investments in both GHG-abatement technologies and climate adaptation measures.

The Author of This Issue

Daniel Schwanen specializes in trade and investment issues, and is the author of a number of articles and commentaries on global warming, Canadian cultural policies, Canada's external trade policy, the impact of free trade agreements, and interprovincial economic issues. He is a frequent commentator on economic affairs in the media.

C.D. Howe Institute Commentary© is a periodic analysis of current public policy issues. The manuscript was copy edited by Lenore d'Anjou and prepared for publication by Barry A. Norris. As with all Institute publications, the views expressed here are those of the author, and do not necessarily reflect the opinions of the Institute's members or Board of Directors. To order this publication, please contact: Renouf Publishing Co. Ltd., 5369 Canotek Rd., Unit 1, Ottawa K1J 9J3 (tel.: 613-745-2665; fax: 613-745-7660), Renouf's stores at 71½ Sparks St., Ottawa (tel.: 613-238-8985) and 12 Adelaide St. W., Toronto (tel.: 416-363-3171), or the C.D. Howe Institute, 125 Adelaide St. E., Toronto M5C 1L7 (tel.: 416-865-1904; fax: 416-865-1866; e-mail: cdhowe@cdhowe.org).

$10.00; ISBN 0-88806-471-3

As the March 2000 joint meeting of energy and environment ministers demonstrated once again, Canadians have a difficult task before them in assessing a range of possible actions aimed at abating the rise in concentrations of greenhouse gases (GHGs) in the Earth's atmosphere. Given their twin responsibilities of maintaining a safe environment and enhancing the economic well-being of citizens, policymakers seem, according to many analyses, to be facing sharply contradictory mandates. This dichotomy need not be an obstacle to action, however, if they take a sensible and realistic approach.

Many scientists fear that the rise in atmospheric GHG concentrations is causing a harmful increase in the Earth's mean surface temperature. The increased concentrations appear to have resulted from the past two centuries' sharp growth in human population and economic activity — in particular, the burning of fossil fuels. In response, on December 11, 1997, the industrial countries (collectively, the "Annex I" countries) — including the former communist countries of eastern Europe that have moved toward a market economy — reached the Kyoto Protocol on the United Nations Framework Convention on Climate Change (UNFCCC). Under it, they agreed to collectively reduce their GHG emissions, averaged over the 2008–12 period, to 5.2 percent below their 1990 levels by 2008–12 (see Table 1).[1]

The Protocol allows each Annex I country's undertaking to differ from that of others. For its part, Canada undertook to reduce its emissions by 6 percent below their 1990 levels. But by 1997 its emissions had already exceeded 1990 levels by some 13 percent (Canada 1999a, xiii). And compared with the GHG emissions forecast for 2010 without any new policy change — that is, the latest "business as usual" scenario — the Canadian reduction commitment now amounts to 26 percent (Canada 1999b, 42).

The problem now is to determine what action Canada should take to meet this commitment. Unfortunately, the Kyoto targets were set without reference to the cost of meeting them (or of their potential benefits relative to those of following alternative scenarios of emissions reductions and time frames). Considering how far Canada is from reaching its Kyoto target, and how closely the emissions of the principal GHGs resulting from human activity are linked with the growth and type of economic activity the country has typically enjoyed, a serious attempt at meeting the commitment within the given timetable would likely involve significant changes in the economy and even in Canadians' lifestyles.

Under these circumstances, a contradiction between this international commitment and the economic well-being of Canadians is probable, according to many studies. It will be difficult to ensure that specific actions, which are taken as part of a well-meant but general commitment to the world's environment, are also taken with the best

---

I profusely thank the many internal and external reviewers for their rich and varied comments on this paper, as well as the presenters, discussants, and other participants of the C.D. Howe Institute Policy Conference on "Turning Down the Heat," held in Toronto on November 18, 1999. Although I have attempted to reflect the different perspectives on this issue, all the good comments provided could not be addressed adequately in the space or time available. As a result, all errors and remaining ambiguities are my responsibility.

1 In addition to the 40 Annex I countries, the parties to the Kyoto Protocol also included more than 130 developing countries that have signed the United Nations' 1992 Framework Convention on Climate Change. However, only the Annex I countries (excepting Belarus and Turkey) agreed to cap their emissions in Kyoto.

Table 1: ***Kyoto Targets for GHG Emissions, by Country***

	Percentage Change in GHG Emissions from Base Period		
North America		*Other Europe*	
Canada	– 6.0	Iceland	+ 10.0
United States	– 7.0	Liechtenstein	– 8.0
		Monaco	– 8.0
Asia and Oceania		Norway	+ 1.0
Australia	+ 8.0	Switzerland	– 8.0
Japan	– 6.0		
New Zealand	0.0	*Countries in Transition to a Market Economy*	
European Union[a]	– 8.0	Bulgaria	– 8.0
Austria	– 13.0	Croatia	– 5.0
Belgium	– 7.5	Czech Republic	– 8.0
Denmark	– 21.0	Estonia	– 8.0
Finland	0.0	Hungary	– 6.0
France	0.0	Latvia	– 8.0
Germany	– 21.0	Lithuania	– 8.0
Greece	+ 25.0	Poland	– 6.0
Ireland	+ 13.0	Romania	– 8.0
Italy	– 6.5	Russia	0.0
Luxembourg	– 28.0	Slovakia	– 8.0
Netherlands	– 6.0	Slovenia	– 8.0
Portugal	+ 27.0	Ukraine	0.0
Spain	+ 15.0		
Sweden	+ 4.0		
United Kingdom	– 12.5		

[a] The EU's overall reduction of 8 percent agreed to at Kyoto will be jointly implemented by its members as agreed by them and indicated here.

Sources: United Nations 1997, annex B; Council of the European Union 1998, appendix 1.

interests of current and future generations of Canadians in mind. This *Commentary* is meant as a contribution toward that goal.

I begin by summarizing the economic issues in GHG reduction, an exercise that informs my assessment of the Kyoto Protocol in the following section. This assessment suggests that, in their bid to reduce global GHG emissions, Canada and other countries may have put such an unrealistic burden on themselves that the implementation of the Protocol itself is in doubt.

Then I use the criteria of effectiveness (in meeting any given target), equity, and feasibility to discuss a number of measures whose adoption could allow Canada to contribute effectively toward emissions-reduction efforts, whether or not these occur under the Kyoto Protocol. For example, it may be possible to concentrate initially on what are called no-regrets policies — those that have a beneficial effect on the environment and increase the standard of living.

After reviewing various options for the longer term, I propose that governments encourage the emergence of an initially voluntary and low-cost system of tradable emissions permits for large emitters, complemented by a system of emissions-reduction credits aimed mainly at more diffuse sources of emissions. This permit/credit system would:

- be flexible enough to adapt to inevitably changing external and internal circumstances;
- be compatible with the international trading mechanisms envisaged at Kyoto;

- initially involve a minimum of redistribution from high emitters to governments and of government subsidies to anyone; and
- provide a financial base for investments in new technologies and carbon sinks.

In the paper's two final sections, I look at some of the issues, international and domestic, raised by the implementation strategy I propose. I suggest that Canada's international negotiating position in the ongoing talks on Kyoto implementation be aimed at maximizing the chances of success of a domestic emissions-permit scheme. The federal government should take a position in favor of a wide interpretation of the Kyoto provisions concerning international emissions trading and firms' gaining credits for projects achieved in non–Annex I countries through the new clean-development mechanism (described below). It should also explore the possibility of formally approaching the United States about a joint implementation of the two countries' reduction targets.

Domestically, Canadian firms (and indeed other emitters) should immediately be able to count toward eventual permit allocations both their current successful emissions-reduction efforts and reduction credits that are acquired through voluntary trades.

The Economics of Reducing Emissions

Even though the Kyoto Protocol, which calls for specific reductions in GHG emissions by country, has already been signed, discussing its potential benefits and costs is important, for two reasons.

Many signatories, including Canada, have yet to make progress toward GHG-emissions reductions.

First and most obviously, the Protocol is not yet in force — as of mid-January 2000, it had been ratified by only 22 countries, not one of which is an Annex I country. Many signatories, including Canada, have yet to make progress toward GHG-emissions reductions that are significant (let alone of the magnitude advanced at Kyoto). Debates on the benefits and costs of the Kyoto targets will doubtless play a pivotal part in ratification debates in Canada and other countries and will be required to ensure ongoing political support for a project whose costs will be incurred beyond the present term of any democratic government and whose payoffs will come even further in the future. If voters come to believe that this project is drawing too many resources relative to the risk posed by higher GHG emissions, countries may choose to return to the drawing board. This possibility must be kept in mind when devising a national strategy.

Second, an overview of the type of benefits the Canadian economy can expect and the costs it would incur from attempting to reach the target will help policymakers and voters choose the specific strategy to pursue. The Kyoto Protocol mostly left the choice of strategies to individual countries. It is thus important for Canadians to think about the types of measures that are most likely to be effective in delivering the expected benefits and that can do so in the way most acceptable in terms of costs, equity, and administrative feasibility.

The Problem

I begin by quickly reviewing the main elements of the policy problem governments are facing.

Concentrations of GHGs

Greenhouse gases in the atmosphere trap solar energy, which the Earth radiates back into space. (Without this phenomenon, the Earth's surface would be so cold as to make life as we know it impossible.) Most GHGs occur naturally, but their atmospheric concentration has increased significantly over the past 200 years. In the opinion of a critical number of scientists, this rise is probably associated with anthropogenic, or human-induced, GHG emissions.

Specifically, the atmospheric concentration of carbon dioxide (CO_2), the most important anthropogenic GHG, was measured at 363 parts per million in 1996 — some 30 percent higher than ice-core measures show them to have been in pre-industrial times (World Resources Institute et al. 1998, data table 16.4). The main anthropogenic sources of CO_2 emissions include electricity generation and other industrial processes, the burning of fuel in vehicles, and the cutting of forests (considered to be carbon sinks because they absorb CO_2), as well as the extraction and transportation of fossil fuels themselves.

Although the growth rate in emissions has slowed from its historical peak and could well be reduced even more by the decreasing carbon intensity of the world economy overall (as documented in, for example, World Energy Council and IIASA 1995, table 4-14), annual CO_2 emissions are nevertheless at an all-time high. Unless they actually fall to a level at which natural systems are able to absorb them, the atmospheric concentration of CO_2 will continue to rise over time. Simply to stabilize this concentration at any level in our lifetimes would require that annual emissions drop by a historically unprecedented amount. A further slowdown in the growth rate would not be sufficient.

The second most significant type of anthropogenic GHG emission is methane (CH_4), arising from waste disposal and agricultural activity, as well as energy production. It is estimated that methane concentration in the atmosphere has more than doubled since pre-industrial times.

Diverse Views of the Impact

The facts about carbon dioxide and methane concentrations are relatively undisputed. The more challenging scientific question is about the impact of these rising concentrations on the Earth's temperature.

The challenging scientific question is about the impact of rising concentrations of carbon dioxide and methane on the Earth's temperature.

Records of instrument measurements show that the global mean land-surface and sea-surface temperature has increased by 0.3 to 0.6 of a degree Celsius since the late nineteenth century (Parry and Carter 1998, 12). These results are not significantly altered by the exclusion of measurements taken near cities, which urban sprawl may bias upward over time (Peterson et al. 1999).

However, controversy surrounds the interpretation of satellite-taken data of temperatures in the lower troposphere, available since 1979. Various scientists now interpret these data as showing either a warming of 0.07 of a degree Celsius per decade or a cooling of 0.01 of a degree.[2]

2 See "A heated controversy," *The Economist*, August 15, 1998, pp. 66–68.

Furthermore, a number of scientists dissent from the view that the increase in the Earth's temperature is due to human-induced GHG emissions. Many other natural factors, such as cyclical variations in the sun's radiance, are constantly at work and could account for a significant part of the observed warming trend. In the past, such factors have provoked significant and sometimes abrupt warming and cooling trends, for which human activity obviously was not responsible (Parry and Carter 1998, 8–11).

The IPCC Report

The Intergovernmental Panel on Climate Change (IPCC) is an umbrella group, convened under the auspices of the United Nations, to summarize the work of hundreds of scientists around the world. Its most recent report (1995) was much cited at Kyoto and by commentators seeking to influence reactions to the threat of global warming.

In fact that report, written in the face of some of the scientific disagreement just described, is cautious. It concludes that the "balance of evidence" suggests that the influence of anthropogenic gases on the Earth's temperature is "discernible" but that it is impossible to "firmly establish a clear connection" between human activities and changes observed in climate extremes and variability in certain regions (since some regions experience greater climate variability than others) (IPCC 1995, 2.4, 2.5).

The IPCC report notes credible evidence that quick reductions in emissions are costlier than longer-term ones.

The IPCC report also notes credible evidence that quick reductions in emissions are costlier than longer-term ones (ibid., 7.6). Indeed, Wigley, Richels, and Edmonds (1996), using the same methodology as the IPCC, show that, in contrast to an immediate GHG-emissions-stabilization strategy, a long-term strategy allowing a continued rise in emissions for the next 20 years or so (if followed by sharper cutbacks beginning in 2050) would be less expensive and would have no impact on atmospheric GHG concentrations in the mid-twenty-second century. On the other hand, potentially harmful phenomena can be influenced not only by concentrations of GHGs in the atmosphere but also by their rate of increase (see, for example, the discussion of factors affecting North Atlantic ocean circulation in Keller et al. 1999), a fact that Wigley, Richels, and Edmonds do not take into account.

Regrettably, the caution that permeates the IPCC report is often not reflected by many who cite it as validating the substantial and rapid GHG-emissions cuts the Kyoto Protocol calls for. The report does, however, state that the evidence justifies eventual mitigative actions (beyond no-regrets measures) if stabilization of GHG concentrations is to be achieved.

The Implications of Uncertainty

Thus, as policymakers continue to assess the likely costs of action and inaction toward reducing GHG emissions, they should realize that uncertainty about the extent and potential costs of the phenomenon facing us and even about its sources remains an important factor to consider when making decisions. Furthermore, while science points to potentially dangerous impacts from human-induced increased GHG concentrations in the atmosphere, the specific targets for emissions reductions agreed to at Kyoto offer nothing particularly scientific or even desirable. The IPCC report, like science in general

(see Harvey 1996, 1) is noncommital about the level at which atmospheric concentrations of GHGs should be stabilized. Rather, it attempts to define the likely impact of some basic scenarios, such as the often-quoted "mid-range" emissions scenario, which implies a doubling of atmospheric CO_2 concentrations between pre-industrial times and the end of the twenty-first century — that is, more than one and a half times current concentrations — and could, according to the report, lead to an average temperature increase of 1 to 3.5 degrees Celsius over that period.

Benefits of Reducing Emissions

The problems that a 1 to 3.5 degree Celsius warming of the planet would likely cause over the next century are well described elsewhere (in, for example, IPCC 1995; Harvey 1996). Potential effects include the disappearance of many coastal lands and islands under rising water levels, reduced arable areas in some regions, increased incidence of tropical diseases and of extreme weather phenomena, such as violent storms, abrupt changes to ocean circulation patterns, and diminished biodiversity. The benefits to the world of acting to reduce GHG emissions can thus be expressed as the reduced likelihood of such unwanted events.

While Canadians may be tempted to think that warmer weather would bring them a higher standard of living — for example, by reducing heating costs or improving agricultural yield[3] — some Canadian ecosystems would likely not adapt well to rapid changes (certainly less well than humans), and some coastal areas would be affected by rising sea levels. Neither could Canada remain immune from the global pressures that are predicted to stem from climatic change, such as diseases and an increased need for water in the United States.

Economists and others attempt to put a dollar value on the problems global warming is likely to cause, although it is important to understand that their results are hugely variable and that the cost of certain events sometimes associated with global warming (such as loss of biodiversity) is inherently difficult to estimate. Cost estimates by region or country are particularly uncertain. (All scientists agree that effects would vary considerably from region to region, since existing climatic models are considerably less accurate in their predictions of effects for specific regions than they are in forecasting overall warming or cooling phenomena.)

The cost of certain events sometimes associated with global warming (such as loss of biodiversity) is inherently difficult to estimate.

Typically, the lowest estimates of damages

> reflect the notion that continued accumulation of greenhouse gases will not produce extreme changes in climate over the next century, and the idea that most economic activities are not exceptionally sensitive to modest climate change. In addition, discounting over long periods of time substantially reduces the benefit estimates, which are present values. (Parry, Williams, and Goulder 1997, 16.)

Studies that use a very low discount rate (to account for the benefits to future generations), as well as extreme values for climate change and the sensitivity of ecosystems and the economy to such change, naturally find higher benefits than others.

---

3 Both would indeed be likely, if temperatures increased 2 degrees Celsius (see Parry and Carter 1998, 103).

Indeed, the question of how to account for the benefits accruing to future generations is a particularly sensitive one in such calculations because even the GHG-emissions reductions agreed on at Kyoto would barely have a measurable impact on average temperatures 50 years from now (Michaels 1998).

Despite the wide range of possible assumptions, the estimated output loss of doing nothing[4] usually ends up being well under 1 percent of global gross domestic product (GDP) over the next century, although some estimates run as high as 2 percent.

More prospectively, some authors also enthusiastically suggest that the benefits from a serious effort to reduce GHG emissions would include a permanently more efficient use of energy and the development of new technologies. Such an effort inevitably would trigger interesting effects, but estimating them now is probably as difficult as it would have been to determine ahead of time the value of the technological advances triggered by World War II or by the 1960s' quest to reach the moon. After all, we will never know what developments were prevented by pouring resources into those two endeavors instead of the alternatives (say, medical advances). The point here is that the potential benefit of new technologies is a byproduct of, but not a reason for, engaging in a major effort to reduce GHG emissions instead of trying to solve other costly problems.

The potential benefit of new technologies is a byproduct of, but not a reason for, engaging in a major effort to reduce GHG emissions.

The Costs of Reducing Emissions

A large body of literature considers the prospective costs of reducing emissions for either the world or individual economies. The results vary widely, partly because analysts use several methodologies and partly because various assumptions and parameters can greatly influence the results of any methodology. Here, I review three broad approaches to analyzing the costs of emissions reductions: the Kaya identity, economic models, and the engineering or bottom-up approach.

The Kaya Identity

The simplest top-down analyses use the Kaya identity. Named after its original exponent (Kaya 1990), this technique breaks down carbon emissions as the product of the carbon intensity of energy use, the energy needed per unit of output (GDP), GDP per capita, and population growth. Emissions reductions can be accomplished only by reducing at least one of these variables. Thus, the identity gives a rough idea of the order of magnitude of the change required in technology, in lifestyle, or in economic or population growth to an economy to the Kyoto targets.

Simple calculations using this identity (made by Dougher and Jones 1998) show that if the Kyoto targets were achieved by changes in only one of the variables, leaving the others constant, one of four things must happen in industrial countries.

- an unprecedented acceleration in the secular trend away from the most carbon-intensive sources of energy toward less intensive ones;

4 Assuming that predictions about warming are realized and that we could, in fact, have done something about the situation.

- changes in industrial structure and lifestyles or new investments in energy-saving equipment that would result in a fall in the ratio of energy consumption to GDP at least twice as important as those that occurred during the 1970s' oil crisis;
- a major downturn in economic growth, essentially reducing the US and Canadian economies to a state of constant recession in the first decade of the new century and economic growth in the European Union (EU) to less than a quarter of current expectations and in Japan to less than a third; or
- sharp, absolute population declines.

Of course, GHG-emissions reductions are likely to take place via changes in more than one variable included in the Kaya identity. But even with a combination of events that was favorable to the reduction of emissions — namely, a reduction in the carbon intensity of energy and in energy use per constant dollar of GDP comparable to the experience of the 1970s, and a halving of economic growth in the first decade of the 2000s relative to projections — the United States would still fall short of its Kyoto target, while the EU would barely meet its own (barring technological developments that would allow low-cost reduction of the carbon intensity of the energy sources in use).

The reduction in GHG emissions contemplated under Kyoto would have effects similar to those of sharply higher prices or the lessened availability of fuels.

Thus, the reduction in GHG emissions contemplated under Kyoto would have effects similar to those of having to shift gears suddenly as a result of sharply higher prices or the lessened availability of fuels and other sources of power. Canadians, who are high users of energy on account of their climate, the vast size of the country, and the weight of natural resources in the economy, are well acquainted with the difficulties that sharp and unforeseen rises in energy prices can cause in their lives. The changes required by the Kyoto Protocol would exceed those of any such occurrences within living memory, including the oil price shock of the 1970s.

The Kaya identity provides an idea of the magnitude of the challenges involved in reducing GHG emissions. It implies that reductions of the magnitude contemplated under Kyoto cannot be achieved without a major national effort. The identity cannot, however, show whether such changes are possible, or what they would cost.

Economic Models

To find at least partial answers to cost-benefit questions, one must turn to behavioral models of the economy and to assessments of the technical constraints and possibilities.

Economic models include behavioral equations that attempt to capture how key economic sectors (consumers, energy and non-energy producers, and so on) or the economy as a whole respond to particular circumstances or policies (such as prices and taxes). Hence, they can be used to forecast reactions to changes. Naturally, results differ according to the specific structure and assumptions underlying particular models. Moreover, models have shortcomings. A particularly relevant one in our case is their inability to incorporate the process of technological evolution in response to a changing environment. (Many models do permit the user to make assumptions about technological change, but they greatly influence the results.)

Within these limitations, most modeling exercises undertaken to date suggest that under only the most extreme warming scenarios or very optimistic assumptions about the effects of adopting new carbon-saving practices or technologies throughout the

economy would the expected global benefits of implementing the Kyoto Protocol exceed the likely costs. This conclusion appear to be especially strong for Canada.[5]

Although economic models provide interesting if uncertain evaluations of the impact of emissions abatement on economic growth, a major use of these exercises is to help us understand the source of these effects. If we are to try to reach an objective, is there a more or a less intelligent way of doing it? In a previous paper (Schwanen 1997), I identify the key factors that various economic models agree would influence the costs of reducing annual GHG emissions:

- The availability and cost of the technological means to improve energy efficiency or reduce the GHG-intensity of energy use in the economy. The measure in either case must be net of the projected outcomes of trends that already exist.
- The period over which the target can be reached. The longer that period, the more time for firms to bring technological improvements on stream during their normal capital stock turnover cycle, rather than taking the expensive route of immediately scrapping existing stock or reducing its use (which would reduce current and future savings available for ongoing GHG abatement or for other desirable investments).
- The extent to which the policy ensures that the least efficient emitters (those that produce the least amount of income for a given amount of emissions) are first in line for reductions. This approach ensures the minimum reduction in existing economic activity resulting from GHG-emissions abatement.
- The extent to which subsidies that artificially stimulate emissions-intensive activities are reduced before other measures are introduced. For example, subsidizing both wind-power research and coal production[6] is inconsistent policy and it makes global GHG-emissions reductions more expensive than they need be.
- The extent to which it is possible to avoid "carbon leakage," which occurs when firms switch their investments to countries with more lenient GHG-emissions-reduction policies.
- The use of any revenues from a tax on GHG-intensive activities. Models suggest that if governments used such revenues to reduce certain other taxes, the negative impact on GDP could be alleviated.[7]

Immediately scrapping existing stock would reduce current and future savings available for ongoing GHG abatement or for other desirable investments.

These qualitative (and in that form generally undisputed) observations about the costs of a GHG-emissions-abatement policy help us to understand how to minimize the costs of reducing emissions — that is, how to meet the efficiency criterion. They also suggest the extent to which we can meet the other criteria of effectiveness in reducing emissions, equity in apportioning the effort between and within countries, and the administrative and political feasibility of the measures invoked.

The Bottom-Up Approach

The bottom-up or "engineering technology" approach concentrates on the technical feasibility and costs of reducing GHG emissions at the level of individual industries,

5 See the review of modeling exercises by Howatson and Campfens (1997); OECD (1998).

6 As Germany, for example, does; see "Cleaner energy," *The Economist*, April 18, 1998, p. 17.

7 These models' implications for Canada are discussed later in this *Commentary*.

plants, and even households. In what ways and at what cost can these units achieve reductions?

This approach offers a richer picture of the technical possibilities. As a guide for action on the scale contemplated under the Kyoto Protocol, however, it suffers from its inherent neglect of the aggregate impact of attempting to implement many individually feasible solutions all at the same time or in short order. For example, if all the changeovers that the many engineering analyses consider beneficial were put in place across the entire economy over a short period, the call on limited human and financial resources would surely raise costs, turning many apparently winning proposals into losing ones. In other words, aggregate resource constraints (for example, interest rates that rise as the amount of financing required increases), which are not considered in these models, would make the changes more gradual — and costly — than they often imply.

Often implicit in the bundle of currently technologically feasible emissions reductions are serious changes in consumers' habits.

Furthermore, often implicit in the bundle of currently technologically feasible emissions reductions that flow from engineering analyses are serious changes in consumers' habits, which would add to the time required to effect the change. Indeed, Harvey et al. note that typically not considered in this approach are "[t]ransaction costs associated with finding out about new energy saving technologies, and programme costs associated with efforts to induce adoption of energy saving or fuel switching measures" (1997, 709n).

Three Kinds of Analysis: A Summary

In short, when considering the costs of implementing a reduction in GHG emissions, one must bear in mind that the challenge is huge and can be met only by influencing some of the four basic elements of the Kaya identity. And there must be a thorough exploration of how it can be met at a technical level, as is done in the typical bottom-up exercise. But the central lessons of the economics modeling exercises provide the most useful input when deciding on medium-term targets, strategy, and policy instruments at the aggregate level.

Broadening the Cost-Benefit Framework

As already suggested, a policy of GHG-emissions abatement alone likely would not meet a simple cost-benefit test. Considerations other than expected monetary cost and benefits can, however, weigh in the balance. I briefly consider some of the key ones here.

Equity Considerations

In real life, policies that lower aggregate income in society are often adopted because they help some groups or individuals whom the political process has deemed particularly worthy of support, even at a cost to the whole polity. Indeed, while economics can inform us of a policy choice's net benefits and costs and their distribution, it says little about whether a particular policy should be implemented on the basis of such findings, if it also fulfills some other objectives, such as redistributional ones.

In the case of policies to reduce GHG emissions, redistributive issues definitely arise. In particular, the cost of doing nothing would likely accrue to future generations and could fall disproportionately on coastal areas and small island countries. The respective results could be intergenerational and geographic inequity.

Uncertainty and Risk

The numbers expressing the likely costs of action or inaction often do not take into account uncertainties or the existence of significant risks. This point is all too easy to overlook when comparing likely scenarios.

Uncertainties can, by definition, affect results either way. Thus, predicting the cost to different societies of an event 75 years from now is extremely difficult because that cost will depend on the evolution of a society itself. As Schelling puts it:

> If the climate change expected 75 years from now were to happen immediately, the most dramatic consequences would be on the incidence of parasitic and other tropical diseases....But any changes in temperature and moisture need to be superimposed on those areas as they are likely to be 50 or 75 years from now....Malaysia and Singapore have identical climates. There is malaria in Malaysia, but hardly any in Singapore. (1997, 9.)

It is thus possible to invoke optimistic scenarios of how adaptable societies are to the types of climatic changes expected to come their way.

Ultimately, the policies that countries adopt toward global warming may depend less on their assessment of the likely costs and benefits of action than on their assessment of the risk that the forecasts are wrong and on their tolerance of that risk.

The risks of inaction may seem far less palatable than the risks of action, even though the most likely outcome may not seem catastrophic.

Thus, when considering something like the risks of extreme weather events posed by global warming — events to which one can attach some probabilities — the risks of inaction may seem far less palatable than the risks of action, even though the most likely outcome may not seem catastrophic. The problem here is that if we do cause something terrible to happen, particularly to things that are hard to value, such as biodiversity, we may not be able to reverse the effect later on. In such a case, we may wish to emphasize the potential costs in the cost-benefit comparison — for example, by emphasizing the emissions reductions that would be necessary to avoid not only likely damage but also other possible (if less likely) and very costly consequences (as done in Keller et al. 1999), or by the equivalent approach of reducing the discount rate used in estimating future costs (Bradford 1997, 6–7).

The Case for Sensible Action

Given even a small risk of catastrophic consequences, it is probably reasonable to classify the idea of stabilizing human-induced GHG concentrations in the atmosphere as the acquisition of an insurance policy. A possible event may be of such unpleasant magnitude that we are collectively willing to pay to reduce the likelihood of its occurring.

This being said, the key to a sensible approach is probably to accept the IPCC's conclusions, *in all their richness*, noting the cautious wording, the variability in expectations of warming between the 1990 and 1995 reports, and the scenarios showing that emissions will continue to rise without the participation of key developing countries.

Moreover, as noted above, analysts who use the IPCC model show that reducing emissions now or reducing them later may not make a difference to overall concentration levels in 50 or 60 years so long as sensible policies are put in place now that will result in reduced emissions down the road. Yet other analysts show that the *rate* at which GHGs are emitted into the atmosphere — not just the level at which their concentrations eventually stabilize — could also be an important determinant of future weather patterns and should, therefore, also be taken into account (see Peck and Teisberg 1994).

An Evaluation of Kyoto

On the basis of the approach just suggested, one can evaluate the ways in which the Kyoto Protocol — a major new institutional element — will bear on Canada's choices in the years ahead. The purpose of this evaluation is to review the contents of the Protocol itself and to clarify where it has limited Canada's policy options, where it has better defined these opportunities, and where it has opened up some new ones.

At Kyoto, the governments of the industrialized countries clearly interpreted the IPCC report as meaning that quick and substantial cuts were necessary without reference to the likely costs or benefits.

At Kyoto, the governments of the industrialized countries clearly interpreted the IPCC report as meaning that quick and substantial cuts in GHG emissions were necessary. They chose to act without the participation of developing countries and to make specific reduction commitments without reference to the likely costs or benefits. In particular, they left open questions about the effect of the Protocol on the international competitiveness of countries such as Canada. On the other hand, they did provide mechanisms to give countries flexibility in the way in which they effect reductions, thereby holding down their potential economic costs.

I examine these features of the Protocol one by one, emphasizing Canada's particular situation where relevant.

Extent and Timing of the Reductions

At Kyoto, the Annex I countries agreed to collectively cut emissions of GHGs by just over 5 percent from their 1990 levels. Targets differ by country, in many cases substantially so from the average (look back at Table 1).

Countries must submit to elaborate annual reporting requirements. Each country's actual reduction has to be observed over the 2008–12 period ("the commitment period"), and "progress" (undefined) in achieving the commitments must be demonstrated by 2005. By that year, countries must also have begun talks on further reductions beyond 2012.

The Kyoto participants agreed that the size and timing of post–2012 cuts should take into account any new scientific evidence on global warming, which is to be reviewed periodically, along with other relevant information, such as technical and economic factors. However, the Kyoto targets themselves can be modified only by an amendment to the treaty (the procedures are described in Box 1).

The targeted reductions apply to the three principal GHGs arising from human activities: CO_2, methane, and nitrous oxide (N_2O) — and also to hydrofluorocarbons, perfluorocarbons, and sulphur hexafluoride, which are replacing chlorofluorocarbons (CFCs).[8] The reductions need not apply to all the gases equally, but the calculation for the three main gases must be applied to the aggregate of their equivalent in CO_2 emissions in 1990.[9] A 1995 base year can be used for the other gases.

Technical experts from UNFCCC, national governments, and academia still face much methodological work, particularly on how emissions in the base year will be inventoried and how changes in emissions arising from land-use changes will be calculated.[10]

Participation of Developing Countries

The developing countries will soon account collectively for most of the world's GHG emissions, yet Kyoto failed to ensure that these countries bear any significant responsibility.

The developing countries will soon account collectively for most of the world's GHG emissions, yet the delegates at Kyoto failed to ensure that these countries bear any significant responsibility for ensuring that their development will be no more intensive in carbon fuels and other GHG sources than that of the rich countries. Policies could have been devised to ensure less GHG-intensive growth in these countries, while allowing for their continued development (see, for example, McKibbin and Wilcoxen 1997), thus respecting well-established principles of vertical and horizontal equity. But governments apparently lacked the will and imagination to secure such a outcome.

As a result, the non–Annex I countries made no commitments beyond those, mostly hortatory and of a very general or reporting nature, already agreed to in signing the Framework Convention on Climate Change adopted in Rio de Janeiro in 1992.[11]

In keeping with their legitimate objective of raising their citizens' standards of living, the developing countries wish to attain high rates of economic growth for the foreseeable future. Yet the structures of some of the most important of these economies are among the most carbon dependent in the world (see Table 2), and continuing current practices may frustrate the industrialized countries' attempts to prevent damaging warming from occurring. These facts require that these developing countries become part of the solution at some point in the near future, perhaps, as Nordhaus (1998) suggests, when their per capita income level reaches an agreed-on threshold.

The developing countries even received special commitments under the Protocol. The Annex I countries agreed to consider "funding, insurance and transfer of technology" in order to mitigate the negative impact of both the expected climate change itself and measures to reduce emissions in rich countries; they also agreed to help developing countries meet their Rio commitments, such as on emissions reporting.

Developing countries themselves are not to blame for this lack of commitment. They were certainly right not to buy into the setting-targets-by-country exercise without knowing what limits on their economic growth they were accepting. While the

8 CFCs are currently being phased out because of their impact on the ozone layer, but the substitutes also contribute to the greenhouse effect.

9 Some former communist countries are allowed to use a slightly earlier base year.

10 For a review of the daunting methodological tasks involved, see Jonas et al. (1999).

11 For example, to take climate-change considerations in their policies and actions, to the extent feasible, and to report on their emissions.

Box 1: *Kyoto's Institutional Provisions*

A number of the Kyoto Protocol's institutional provisions remain to be fleshed out. This situation, noted in the text, must be considered in designing Canada's implementation strategy. The broad institutional provisions of the agreement will also influence how effective it can be in reaching its objectives.

Adoption and Entry into Force

Countries had until March 1999 to sign the Protocol, after which they could begin to formally accede to it. The treaty will come into force after countries accounting for 55 percent of emissions among Annex I signatories have deposited their instruments of ratification, acceptance, approval, or accession with the United Nations. The approximate breakdown on emissions between Annex I countries as of 1992 was

	(percent)
United States	36
Canada	3
Japan	8
Western Europe	23
Russia and former communist countries of eastern Europe	28
Australia and New Zealand	2

None of these entities had actually ratified the Protocol as of January 2000.

Amendments and Penalties for Noncompliance

Amendments to the Protocol are to be achieved by consensus whenever possible. If it cannot be achieved, the amendments require approval of three-quarters of the parties to the Protocol (Annex I and non–Annex I countries alike). It seems that amendments would be binding only on those parties that have formally accepted them.

The amendments that will be discussed will include a mechanism for binding penalties in case of noncompliance. At this stage, it is difficult to predict how the global community would deal with a noncomplying country that had signed on to the agreement or an amendment to it.

Withdrawal

A country may withdraw from the Protocol at any time after three years from the date the agreement has begun to apply to it.

benefits of GHG-emissions reduction by rich countries will accrue overwhelmingly to developing countries (since they will hold 90 percent of the world's population in 75 years, and their vulnerability to agricultural disruption under a warming scenario is high), they understand that "their best defense against climate change and vulnerability to weather in general is their own development....Furthermore, they have immediate environmental problems...that demand earlier attention" (Schelling 1997, 8).

International Competitiveness

It is not clear that the Canadian delegates at Kyoto were aware of their decisions' potential effects on competitiveness. Yet the burden of the agreement is not the same for all participants now and it may shift even more in the future.

Table 2: *World's 20 Largest Economies, Ranked by CO_2 Dependency of Output, 1995*

	Thousands of Tonnes of CO_2 Emissions[a] per $ Millions of GDP		
Russia	2.54	Turkey[b]	0.49
China[b]	0.88	United Kingdom	0.48
Australia	0.83	Netherlands	0.44
United States	0.76	Japan	0.41
South Korea[b]	0.72	Spain	0.40
Iran[b]	0.70	Thailand[b]	0.39
India[b]	0.69	Indonesia[b]	0.38
Canada	0.68	Italy	0.36
Mexico[b]	0.58	Brazil[b]	0.29
Germany	0.51	France	0.28

[a] From fossil fuel burning and cement manufacturing.

[b] Countries whose emissions are not capped by the Kyoto Protocol.

Sources: World Resources Institute 1998, data tables 6.1, 16.1; and author's calculations. These calculations used GDP based on estimates of purchasing power parity; basing the amounts on actual 1995 exchange rates would have resulted in estimates of carbon dependency for Russia and all noncapped countries in the table, except Brazil, that were much higher relative to Annex I countries.

Canada *vis-à-vis* Other Countries

At Kyoto, Canada agreed to reductions that seem in line with those of its major trading partner (look back at Table 1). But the impression is belied by the choice of 1990 as the common base year. Canada was entering a recession that year. In contrast, Japan and many European countries were still experiencing an economic boom that artificially inflated their emissions that year relative to Canada's.

The EU, unlike Japan, did agree to reductions from the 1990 base year that are larger than Canada's. Nevertheless, it may well have gained a competitive advantage in Kyoto. It was and is already closer to achieving its targets through a combination of past "easy greenery" measures (such as reduced coal-mining subsidies — easily replaced by natural gas found in the North Sea in the 1970s), practical destruction of inefficient industries in former communist countries,[12] and population growth slower than that of Canada, the United States, or Australia. On these counts at least, the cost of achieving the target will be lower, especially since the targets of individual EU members are tied to their particular circumstances.[13]

It is true that many European countries have also curbed emissions through genuine effort, in particular by levying fuel taxes that are much higher than those in North America. But the EU was able to reward already less carbon-intensive economies, such as Sweden and France (both on account of their nuclear generation capabilities), with small increases or no change in future emissions under Kyoto partly on the strength of reductions that had already occurred elsewhere in the EU (in Germany and the United Kingdom).

12 By 1994, Germany's emissions were already 20 percent below 1990 levels.

13 The issue of accounting for energy and other industrial subsidies is raised only indirectly in the Protocol, which merely suggests that such subsidies be discouraged.

Given the increasing trade and investment links between developed and developing countries, a certain amount of CO_2 will undoubtedly leak to developing or even former communist countries, which are less energy efficient. That is, some Canadian emissions-intensive activities, such as the extraction or harvesting of some natural resources, may well be forced to expand where no targets exist (South America and southeast Asia, for example). Countries with emissions allowances in excess of their actual emissions may even choose to attract industry to their territory by dangling these rights in front of potential investors, rather than selling them to Canada or other potential competitors.

Another factor affecting Canada's competitive position under the Kyoto Protocol is the fact that economic growth in this country has, since the 1960s, depended significantly more on investments in structures (construction) than in the United States. Unquestionably, this dependence could become more expensive under the Protocol, as construction costs (cement, transportation of materials, borrowing costs) would certainly be affected by any policy to reduce carbon-intensive activities over a short period. Such a shift would affect Canada's relative attractiveness as an investment location.

In Future Years

As already noted, the Kyoto Protocol makes it difficult to modify targets in light of new information and circumstances, which are bound to change over the next 15 years. Alterations to the targets require a formal amendment to the Protocol. As a result, countries that discover or begin to exploit new sources of carbon-based energy will be penalized, even if these could usefully displace more carbon-intensive sources of energy elsewhere in the world.

This problem could be alleviated by an international emissions-trading scheme, as is provided for under the Protocol. But some countries heavily reliant on future energy-related developments, such as Norway and Iceland, managed to sign on to Kyoto with emissions-reduction requirements that are significantly smaller than Canada's.

In theory, the problem could also be alleviated by Canada's receiving emissions-reduction units from the United States or jointly implementing with it GHG emissions reductions recorded there but made thanks to natural gas or electricity imports from Canada. In practice, however, this scheme would require official approval from the United States, which would likely be forthcoming only if Washington made the strategic evaluation that Canadian energy necessary to US needs would not be developed otherwise.

Canada could also be hurt by the Protocol because of immigration, which traditionally has been considered an important source of growth for the country. Yet immigration may eventually come to be seen as less a benefit than has been the case because population growth is one of the main contributors to emissions of greenhouse gases (Harvey 1995, 2).

Population growth is one of the main contributors to emissions of greenhouse gases.

Ability to Make Least-Cost Reductions

On the positive side, the Kyoto Protocol goes a significant way toward ensuring that GHG-emissions reductions will occur where they are less costly to make. It does so in a

number of ways that will acknowledge the validity of certain actions other than actual emissions reductions in an Annex I country, provided the outcome is that emissions are reduced (or absorbed through carbon sinks) somewhere in the world.

Specifically, an Annex I country will be allowed to count toward its emissions-reduction commitment:

- changes in the rate at which carbon sinks are created (or destroyed) on its territory;
- emissions-reduction units acquired when it (or a "legal entity" authorized by it) participates in projects in other Annex I countries that reduce emissions there (the country in which the project takes place must agree to this exchange);
- credits purchased from other Annex I countries that have exceeded their reduction targets — or two countries can simply agree to jointly implement reductions, allowing one to increase emissions above its target provided the other comes under target by the same amount;
- contributions to projects or activities that reduce emissions in non–Annex I countries (the precise workings of this clean-development mechanism have yet to be defined, but it may involve private or public entities, and the country receiving the project must agree to it); and
- over-target reductions from a previous year that have been banked.

These options will likely give countries a certain amount of flexibility in contributing to their overall reduction targets, presumably at the least cost to them (or the "legal entities" within them).

Nevertheless, only a limited amount of the reductions can be obtained through emissions trading, which, according to the Protocol, can only supplement reductions that take place within the respective territories of Annex I countries. Countries are still negotiating how much of a supplement emissions trading can be, but if the constraints on where reductions that count have to occur are too severe, the cost of implementing the Protocol will be unduly increased for the same environmental result.

If the constraints on where reductions that count have to occur are too severe, the cost of implementing the Protocol will be unduly increased.

The Tools for Implementation: An Assessment

The domestic policies that Annex I countries use to reach their targets will have the biggest impacts on the overall cost of reducing emissions. Thus, this section of the *Commentary* reviews some attributes of the key types of policy instruments available at the domestic level and evaluates them on the basis of four criteria relevant to policymaking: effectiveness in reaching the objective; efficiency in terms of minimizing the economic cost of reaching the objective; equity considerations; and feasibility, understood here in both an administrative and political sense.[15]

The choice of criteria stems from my view that, to be effective in reaching a particular target, measures adopted have to be cost-effective, equitable, and administratively simple if they are to avoid putting the competitiveness of Canadian

15 I treat effectiveness and efficiency independently from each other here because, under the Kyoto Protocol, the objective to be pursued has been decided without reference to an explicit cost-benefit framework. Hence, I use effectiveness to refer to the likelihood of attaining the objective and efficiency to refer to how a pre-established target can be reached at the lowest possible cost, rather than to which target is optimal given the costs.

businesses at risk and to garner political support over the generation or more that will be required to address the issue.

The available instruments can be divided into three broad categories:

- nonmarket instruments, whose essence is some form of government directive to market players, mandating how or where they should reduce emissions;
- market instruments, which provide an overarching economic signal (such as price changes or a tax) to market participants that will induce them collectively to reduce emissions by a certain amount but generally let them make their own choices about how and where the reduction occurs; and
- "soft" instruments, which increase the ability to undertake emissions-reducing activities but which cannot be used with precision to reach a particular target.

Nonmarket Instruments

A variety of nonmarket instruments is available to governments as they attempt to reduce GHG emissions. Two that are sometimes proposed, though coercive in nature, are mandatory emissions controls and mandatory product standards.

Mandatory Emissions Controls

Mandatory emissions controls would specify where and by how much reductions in emissions would occur. This potential way of dealing with emissions rates only a brief mention here because it is generally not under serious consideration by governments or nongovernmental organizations (NGOs) that are working toward the reduction of GHG emissions.

Mandatory controls would require governments to obtain and analyze huge amounts of information on current output, technologies, and processes.

Worth mentioning, however, are the reasons for this lack of popularity. Although mandatory controls likely would achieve their emissions targets, they could not do so at the lowest possible cost to the economy because they would require governments to obtain and analyze huge amounts of information on current output, technologies, and processes. Furthermore, such a command-and-control approach would likely result, over time, in a fight for politically driven allocations of emissions-intensive activities. Such measures must, therefore, be rejected on efficiency, feasibility, and equity grounds.

Mandatory Product Standards

Mandatory product standards involve specifying the features or performance of a particular type of product — in this case, one whose production or consumption results in GHG emissions. Although this form of government intervention exhibits some features of the command-and-control approach, it deserves more serious consideration than mandatory emissions controls for several reasons.

First, such a policy is suitable for situations in which standardized products are produced by a few firms but consumed by many individuals (regularly mentioned examples are automobiles and electrical appliances); that is, they are products for which information about availability and characteristics is readily accessible but for which it is difficult to monitor actual emissions because of the large number of users.

Yet the attractiveness of standards is often exaggerated. For example, since cars emit a predictable amount of CO_2 by burning fuel, a policy-induced increase in the price of gasoline at the pump could have the same effect on GHG emissions as emissions standards for automobiles (Schwartz 1997).

Indeed, policymakers may find mandatory product standards attractive precisely because they are not transparent. When the cost of a measure is not directly visible to consumers, it is often more politically feasible than alternatives, such as taxes.

The efficiency properties of mandatory product standards are also questionable. For example, a product generating emissions above those allowed by a particular standard may be demanded by purchasers who are willing to pay for equivalent emissions reductions elsewhere in the economy. Yet a mandatory standard would prevent such an economically useful (and environmentally harmless) transaction.

In dynamic terms, a major drawback of product standards is that they do not motivate manufacturers to improve beyond the minimum required, as would occur if emitting firms or their customers had to pay for the GHG emissions they generated.

Mandated product standards can also create significant equity problems. The first is the difference in the treatment of those who made or purchased the product before the standard was imposed and of those who did so afterwards. The second is the often regressive impact on low-income purchasers, an effect not always easy to evaluate or to remedy via fiscal transfers.

Mandatory product standards may be useful in certain circumstances, but only after it is clear that market-based solutions would be highly impractical.

On balance, mandatory product standards may be useful in certain circumstances as a means of contributing to Canada's emissions-reduction target, but only after it is clear that market-based solutions would be highly impractical, either administratively or politically in a given case. This being said, information on high standards should be disseminated and their adoption encouraged, a point I discuss below.

Market Instruments

Market instruments are increasingly applied to environmental issues, thanks to their effectiveness in solving problems and their efficiency in doing so at a reasonable price.

The key role of the market instrument in an environmental context is to impose private costs on the unwanted activity, costs that are substantial enough to lead to its reduction by a desired amount overall. Unlike mandatory rules, these instruments allow a large number of separate decisionmakers the effective choice of exactly how, where, and by whom the reduction will take place. They will act through their responses to the added cost of the undesirable activity (in this case, emitting GHGs). Given that the decisionmakers collectively possess accurate information regarding costs, the use of market-based instruments means reductions can be expected to occur where they are least costly for the economy as a whole.

Various such instruments are already being used to reduce environmentally harmful or risky activities, and others are being discussed in the literature.[16] In general, they involve either a tax on a certain undesired activity, which results in a reduction in that activity, or an overall quantitative limit on the extent of that activity in the economy — for example, through issuing only a given number of permits, which must

16 For an overview of the current use of market instruments in Canada for environmental purposes, see CCME (1996). A general discussion of the pros and cons of various instruments can also be found in Canada (1992); Rhéaume (1993); and Schwanen (1997).

be remitted when performing the activity. In the latter case, market players are allowed to buy or sell the permits to each other, thus setting a price on the activity. The marketplace ultimately decides who ends up with the permit.

Putting a certain price on the activity will result in the production of a given (uncertain, although estimable) quantity of it, while limiting the amount of that activity will result in a given (also uncertain, although estimable) price for it. In that sense, there is a fundamental unity between the efficiency and effectiveness of the two kinds of market-based strategies.

The choice between market instruments involves important equity and feasibility considerations.

The choice between market instruments involves important equity and feasibility considerations, however. In particular, limiting the quantity of GHG emissions involves choosing a way to initially divide the permits or allowances among emitters. The permits can be auctioned or distributed according to a set formula (for example, grandfathering of existing emissions or some variation thereof). Although the initial distribution will have no effect on emissions reductions' overall cost to the economy since the market will still ensure that they take place where they are cheapest, it will affect where newly created "rents" (from making scarce what was previously free) will be distributed.

The following look at the carbon tax and tradable permits examines these equity and feasibility features in more detail. I also address the role of emissions-reduction credits and of removing perverse environmental incentives as part of the set of market-oriented measures.

A Carbon Tax

A carbon tax is applied on the basis of the carbon content of energy sources. Different fuels are thus taxed at different rates per unit of energy according to their carbon content.[17] For example, energy produced from coal is taxed at a higher rate than energy produced from oil, and energy produced from natural gas attracts still a lower rate. To the extent that the tax results in a uniform price for various sources of GHG emissions whose carbon content differs, it can ensure that emissions reductions occur where they are least expensive to make in the economy.

A carbon tax has two other features that are said to make it attractive as a means of reducing GHG emissions: administrative feasibility and revenue-raising capacity that can allow governments to reduce other taxes that distort the economy.

Administratively, a tax on fuels, levied at a few choke points, such as refineries or retailers, may be the easiest way to get at emissions from sectors in which myriad sources collectively contribute to the problem (such as household heating and automobiles). In such cases, taxing fuels is easier than attempting to control or monitor the various sources of emissions. And many jurisdictions already collect taxes, such as excise taxes, at these choke points (or near them in the distribution network), so little new administrative infrastructure is needed.

Moreover, studies show that using a carbon tax's revenues in particular ways can significantly reduce its overall negative economic impact while hitting carbon-energy-

17 The ability of a carbon tax to distinguish among the carbon intensity of various fuels makes it distinctly superior to a simple energy tax. The latter is costlier to apply for a given amount of GHG reduction because it cannot discriminate between more or less GHG-intensive fuels. A number of countries have begun taxing fuels on the basis of their carbon content (see Canada 1998, 9.6).

intensive activities and reducing taxes on others. This result obtains in a number of modeling exercises in which the revenues from a carbon tax are applied to reduce other taxes that distort economic activity, such as payroll taxes (shown by Parry, Williams, and Goulder 1997 for the United States, and by McKitrick 1997 for Canada), or are used for a combination of an enhanced investment-tax credit and a reduced corporate income tax (shown by Shackleton et al. 1992 for the United States and cited in Harvey 1996, 49).

Note, however, that these exercises show that substituting an environmentally motivated carbon tax for certain other taxes has either a positive impact on average incomes or a negative impact that is small relative to a situation in which a new tax was imposed without reducing existing ones, and which is more than offset by the positive environmental consequences of the tax.

Thus, these "double dividend" results are not as helpful to Canadian policymakers as they appear initially. Given the first type of result, one must ask why an approach that would increase average incomes is not implemented regardless of the debate over GHG emissions. The second result implies that, for a country to obtain net benefits from substituting one tax for another, the new tax must have the effect of improving the environment. As we have seen, however, it is not possible for a country the size of Canada to affect the path of global warming alone. Hence reaping the double dividend from carbon taxation depends on what other countries actually achieve.

Reaping the double dividend from carbon taxation depends on what other countries actually achieve.

In short, when the double dividend argument is invoked as a reason for proceeding with carbon taxation and lowering other taxes, proponents are generally abstracting from the reasons such a potentially attractive switch is not attempted in the first place (a prime candidate is redistributive considerations) or from the possibility that, without matching action by competing emitters, a Canadian tax would create net economic losses, by, *inter alia*, putting domestic producers and users of carbon fuels at a disadvantage relative to their foreign competitors with no environmental benefit whatsoever.

In addition, a carbon tax would present significant problems, some specific to the Kyoto process or to possible future substitutes:

- Governments would constantly be tempted to use the revenues for other purposes, reducing, eliminating, or even reversing any efficiency advantages of the tax.
- Once the tax was imposed and other taxes reduced (or the money spent), reducing it would be difficult. If, for example, other countries did not follow with similar measures, some Canadian industries saddled with the tax (for example, the transportation industry) could be at a permanent disadvantage.
- The tax would offer no immediate compatibility with a global system of trading emissions permits such as that envisaged by the Kyoto Protocol. If firms could not get relief from the tax for projects that reduced emissions abroad, there would be no incentive to use Kyoto's important flexibility mechanisms. But if they could get such relief, government would lose anticipated revenues. Also, a carbon tax would reduce incentives for governments to buy credits abroad, even though this might be the least-cost strategy for the economy as a whole. Would governments really reduce the tax to allow more emissions once the domestic emissions cap had effectively been raised by the purchase of emissions credits?

- Similarly, "[t]axes make the development of risk sharing options, equivalent to those in a permit futures or options market, less feasible" (Cramton and Kerr 1999, 1).
- The tax would be highly visible and thus likely unpopular relative to a permit system or a standards approach to reducing emissions. Strengthening this observation is the generally admitted proposition that a carbon tax would, like other emissions-reducing measures, have significant regressive impacts (see, for example, Hamilton and Cameron 1994). A carbon tax would, however, make it relatively easy to redistribute some of the proceeds to low-income individuals.

These features generally make reducing emissions more difficult and costly. They should, therefore, be weighed against the relatively simple administrative features of a carbon tax.

Tradable Emissions Permits

Under a compulsory system of tradable emissions permits, a government puts a legal ceiling on the total amount of emissions allowed by its citizens and legal entities during a given period and allocates or auctions the permits to national emitters, who can trade them domestically or internationally.[18]

No matter how the permits are initially allocated, their exchange within a market system induces emissions reductions where they are least costly for the economy.

The tradability of permits is what most distinguishes this system from a mandatory controls system. No matter how the permits are initially allocated, their exchange within a market system ensures the existence of a single price for all emitters within that system and hence induces emissions reductions where they are least costly for the economy as a whole (see Table 3).

The environmental success of tradable permits at a cost to the economy lower than that of alternatives has been demonstrated in a few cases where they have been implemented under good conditions.[19] An example is the sulphur emissions trading scheme introduced by the 1990 amendments to the US *Clean Air Act* (see Schmalensee et al. 1998). The few but convincing success stories are probably one of the reasons tradable permits are gaining qualified acceptance by environmental NGOs (Hornung 1998b).

Equity Considerations. The benefits of tradability do not mean, of course, that the initial allocation of permits is of no consequence. Indeed, important equity issues arise here. Should existing emitters be grandfathered and issued valuable permits without charge, on the grounds that they now effectively have free use of the new type of valuable instrument that would be created by this scheme? One problem with this proposal is that backers of new fixed investment projects would have to purchase rights from

18 If trading was allowed internationally, there would be an upper bound on the aggregate emissions of all the countries that permitted such trading across their borders. But if the permits are not tradable internationally, this scheme is the same as setting a legal upper bound on the total emissions allowed within the individual country.

19 These conditions included a large enough number of participants experiencing significant differences in their cost structure, which induced them to take advantage of the ability to trade, as well as conditions related to the market itself, such as the ability to carry inventories of permits and to prevent market power from being obtained by only a few firms (Muller and Mestleman 1998).

Table 3: ***Savings from Emissions Trading***

Company A	Company B	Result
	Assumptions	
Facility is 5 years old	Facility is 20 years old	
Target reduction of CO_2 emissions is 5,000 tonnes per year	Target reduction of CO_2 emissions is 5,000 tonnes per year	Total reduction of emissions is 10,000 tonnes per year
Cost of reducing emissions is $2.00 per tonne	Cost of reducing emissions is $10.00 per tonne	Average cost of reduction is $6.00 per tonne
	Scenario 1: Emissions Trading Not Allowed	
Cost of a 5,000 tonne reduction is $10,000 per year	Cost of a 5,000 tonne reduction is $50,000 per year	Total cost of a 10,000 tonne reduction is $60,000 per year
	Scenario 2: Emissions Trading Allowed	
Company A reduces its CO_2 emissions by 10,000 tonnes per year and sells 5,000 credits to Company B for $3.50 per tonne	Company B buys 5,000 credits from Company A at $3.50 per tonne each year	
Company A incurs costs of $20,000 (10,000 tonnes at $2.00 per tonne) less revenue of $17,5000 ($3.50 per tonne for 5,000 tonnes) for a net cost of $2,500	Cost to Company B to purchase 5,000 tonnes of credits per year is $17,500	Total cost of reducing CO_2 emissions by 10,000 tonnes per year is $20,000
	Savings of Scenario 2 over Scenario 1	
$7,500	$32,500	$40,000

Source: Haites 1997; reproduced (with modifications) with the permission of the National Round Table on the Environment and the Economy.

existing emitters — an unfair and inefficient situation if it discourages new entrants at the expense of established firms.

Or should permits be auctioned off anew, on the grounds that emissions contribute to a socioeconomic evil that needs to be corrected? This approach is formally the same as that proposed for the carbon tax under the double dividend argument, and it exhibits exactly the same problem: since domestic emitters are but a minuscule source of the evil, focusing on them is efficient only if it is part of a similar approach by all geographical sources of emissions. In addition, the auctioning of permits exhibits the first two other drawbacks identified above with respect to a carbon tax.

These questions are magnified in the Canadian federal context, in which cooperation between levels of government is of great importance to achieving reduction objectives.[20] Here the equity issue is complicated by the fact that the policy's impact could differ considerably by region. Faced with this political question, decisionmakers may put a premium on grandfathering, thereby limiting the transfer of

20 A study comparing the jurisdictional framework relevant to GHG-reduction implementation in three federations concludes that "the different national governments have significantly different capabilities to implement and achieve, *inter alia*, CO_2 and GHG reduction targets. The German government has the strongest capability, the US federal government a moderate capability, and the Canadian federal government the weakest capability," with the Canadian provinces conversely exhibiting the "greatest autonomy" in this respect relative to the US states and German *Länder*. The authors point out, however, that ratification of the Kyoto Protocol will probably strengthen the influence of all three federal governments on policies to reduce GHG emissions (Deangelo and Harvey 1998, 133).

wealth between regions implicit in auctioning permits (or in a federally imposed carbon tax).

Feasibility Considerations. The most significant feasibility issue a permit system faces is the difficulty of covering all current emitters. The multiplicity and diversity of emissions sources are huge. As Cooper puts it:

> Monitoring the consumption of fossil fuels is more or less manageable since most of it must pass through some relatively narrow choke points like gas pipelines, oil refineries, and electricity generating stations. Most coal production can be monitored at the mine head or on the barges and railroads that transport it....But this still leaves out a lot of greenhouse gas emissions....Other important culprits include burning tropical forests, the use of wood as fuel, livestock and rice cultivation, town dumps, and leakage from gas pipelines. (1998, 73.)

An emissions permit scheme cannot be fully effective, efficient, and equitable without measures to ensure that emitters that cannot practically fall within the scheme still contribute to the reduction effort.

Thus, an emissions permit scheme cannot be fully effective, efficient, and equitable without complementary measures to ensure that emitters that cannot practically fall within the scheme still contribute to the reduction effort. This requirement applies particularly to the producers of some of the 23 percent or so of GHG emissions in Canada that do not come from fossil fuel combustion.[21]

Tradable Emissions-Reduction Credits

If policymakers wish to avoid widespread regulation but judge that non–fossil fuel combustion sources offer untapped but economically feasible reductions in GHG emissions that economic agents could explore with the proper incentive, then a system of emissions-reduction credits could draw out this potential. Such a system would see emitters *earning* tradable credits over time for initiatives leading to verifiable declines in emissions that exceed a certain standard.

A key advantage of adding credits to an emissions-permits system is that it would enable "responsibilities to be extended to more sources; small, difficult-to-regulate sources often escape regulation leaving a proportionately larger onus for emissions reductions on large stationary sources" (Haites and Jantzi 1996, 5). A possible disadvantage is that determining the validity of credit claims from a number of small sources could involve large administrative costs.

Removal of Perverse Incentives

Finally, the removal of harmful incentives — those that actually encourage the activity beyond what would occur in an unhindered market — is also an important market-based instrument.

---

21 These include emissions from landfills, various agricultural processes ("enteric" emissions — mostly from ruminants — fertilizer use, and livestock manure), and certain industrial processes, notably in the aluminum, lime and cement, and magnesium smelting industries, as well as fugitive emissions from energy production and transmission (NRTEE 1999b).

Case studies show that, although it is not possible to generalize about the environmental effects of removing subsidies, common action by Annex I countries on reducing grants and price supports to coal producers, removing sales tax exemptions for various forms of energy and subsidies for energy-intensive industries, and eliminating subsidies to supply remote areas could have a significant impact beyond 2010. These possibilities are tempered, however, by difficult political and competitiveness considerations (Michaelis 1997).

Soft Instruments

"Soft" instruments are types of initiatives that can help Canadians explore or acquire new means of reducing emissions and make such reductions less costly. But they can affect emissions, for a given amount of effort or money, in a way more diffuse and hence less certain than market instruments or *a fortiori* coercive measures, such as standards and regulations. The soft instruments briefly reviewed here are the encouragement of voluntary action to reduce emissions; the provision of better information to decisionmakers and to the general public about their available choices; and encouragement of research and development.

Voluntary Action

A voluntary program of increasing scope has been in place in Canada since 1995, when the establishment of the National Climate Change Voluntary Challenge and Registry program (VCR) formed the centerpiece of the newly minted national strategy on climate change. Critics of the program point to the fact that it has not led to an actual decrease in emissions, nor are companies and organizations registered under the program moving much beyond declarations of intentions.[22]

It is important, however, not to confuse this early evaluation with how the program could be part of a broader, longer-run initiative. It has almost certainly contributed to the fact that industry has been a leader in Canadian emissions abatement relative to other sectors, such as households and government. Moreover, reductions are cheaper to the economy when made over the normal capital stock turnover period, which is typically every to 20 to 40 years in Canadian energy-intensive industries. Only a few years into the program is much too early to pronounce it a failure.

Voluntary programs are more likely to result in an awareness and implementation of no-regrets measures than in any firm's adopting costlier measures.

Voluntary programs are, nevertheless, more likely to result in an awareness and implementation of no-regrets measures than in any firm's adopting costlier measures that would benefit only its competitors, Canadian or foreign, unless they were also adopting them. Hence, Canada is unlikely to achieve reduction targets of the scope envisaged in Kyoto without more compelling measures.

The existing voluntary reduction program thus probably scores insufficiently on the effectiveness scale. It may also be low on efficiency if it turns out that monopolies and quasi–price-makers respond more than price-takers to such programs. In that case, reductions may not correspond to the relative marginal costs of abatement.[23]

---

22 Some have inventoried emissions and made commitments to future action, but, in practice, very few have taken the latter step (Hornung 1998a, 11; Hornung and Bramley 2000, 7–11).

23 E-mail from Mark Jaccard to the author.

All told, however, the voluntary infrastructure already in place should be used, at least for the gathering of information and the monitoring of progress that will be required for the success of a more market-oriented program, such as one involving tradable emissions permits.

Information Dissemination

Some authors (for example, Harvey 1996) believe many unexploited no-regrets measures exist. If so, a national strategy focused on efficiency would devote resources to informing individuals and businesses about them, before governments attempt to capture these reductions with incentives on compulsory standards.

Research and Development

One area yields a similar message whether analysts look at the issue of emissions reduction from either the top down (Kaya identity or behavioral economic model) or the bottom up: the ability of the Canadian economy and society to handle changes such as those contemplated under the Kyoto Protocol will depend critically on the emergence of new technologies or the ability to lessen the cost of potential replacement technologies that already exist, especially since some countries, such as Sweden, are phasing out nuclear energy.

The ability of the Canadian economy and society to handle changes such as those contemplated under the Kyoto Protocol will depend critically on the emergence of new technologies.

Further reductions from other currently available substitutes (solar power, wind biomass, hydroelectricity) are severely limited by the availability of large suitable areas, and they are unlikely ever to replace more than a portion of existing carbon-based fuels (Lightfoot and Green 1998). Even the rapid development of fuel-cell technology to replace the traditional combustion engine (Walton 2000, B1) is tempered by the fact that fuel sources cleaner than gasoline will be needed to manufacture hydrogen itself if the new engines are to have a significantly positive impact on the environment (Pembina Institute for Appropriate Development and David Suzuki Foundation 2000).

Hence, companies and governments have begun to invest heavily in new technologies, and although the results are inherently uncertain, more R&D efforts are almost certainly part of the solution to reducing GHG emissions.

The best boost to R&D in this area, however, is probably the signal that market demand for such technology will exist in the future — in other words, that emitters will adopt the new technologies as a way of avoiding taxes or the purchase of costly emissions permits. Hence, any discretionary amounts for R&D coming out of public budgets should supplement, not lead, a system whereby the right pricing incentives are provided.

Interaction with the Rest of the World and Future Events

Canada's choice of policy instruments and the timing of their implementation cannot be independent of factors external to the domestic situation, for at least two reasons. First, policies that rely on, for example, trading in foreign emissions credits must be attuned to the possible emergence of such a system. Second, if other countries balk at

implementing the Kyoto Protocol, Canada could be left holding the economic bag (costs) while no benefit is achieved from its actions.[24]

Seeking Compatibility with Global Mechanisms

As roughly outlined above, governments at Kyoto agreed on a number of mechanisms that build flexibility into how much of a country's emissions reduction must occur domestically. They allow countries to purchase credits for reductions made abroad if they cannot make them at home as efficiently, and to earn credits for emissions-reduction projects by their nationals in non–Annex I countries.

These mechanisms are hugely important if the Protocol, or any similar international agreement, is to have a future. They permit environmentally desirable emissions reductions to be achieved economically where the cost of doing so is lowest.

Accounting for the Possibility of Breakdown

Any prudent strategy for Canada must consider the possibility that other Kyoto signatories will not meet their commitments.

Even if a satisfactory enforcement mechanism is found for the Protocol, any prudent strategy for Canada must consider the possibility that other Kyoto signatories will not meet their commitments. An enforcement mechanism is unlikely to be effective if a critical mass of countries is simply unable to meet their commitments, as is indeed possible.[25] This situation would differ from one in which, say, Canada managed to achieve significant reductions domestically, whereas another country had great difficulty doing so. In that case, Canada's reductions could be converted into credits to be purchased by the country that was struggling to meet its target. This outcome would be consistent with Kyoto, as it would allow Canada to benefit from its relatively more aggressive reductions.

If Canada does not wish simply to wait for other countries before addressing its own strategy, the choice of instruments and the timing of their introduction should be flexible enough so that we are not left in economic limbo should the goals of the Protocol be only partly achieved globally. It is worth stressing the main reason for such a prudent attitude: the environmental benefit of Canada's making some unilateral reductions in GHG emissions would be infinitesimal, perhaps negative, while the economic costs would be substantial.

A Suggested Implementation Strategy

Given the considerations just presented, I now turn to a proposed implementation strategy.

---

24 A third possibility, less likely but similar in effect to the second, is that the scientific consensus will shift in a relatively short time and the threat of warming from human activities will have been found to be less than previously thought. Another possibility is that acceptable ways will have been found to counter that threat more cheaply through adaptive measures.

25 On the poor "regime sustainability" of Kyoto, see McKibbin and Wilcoxen (1999).

The Case for Sensible Domestic Action

By signing on to the Kyoto Protocol, Canada and other countries have created a policy challenge for themselves. Canada agreed to meet stringent targets without an internal consensus or public plan on how to do so and without knowing how competitors intend to meet their commitments. This approach is akin to going on a difficult climbing expedition without having taken stock of the available equipment or considered the alpinists' morale.

The same assessment applies to many other signatories, and the absence of planning may well result in the agreement's not being ratified by enough countries to bring the treaty into force (look back at Box 1). Canada must, therefore, take a careful approach toward implementation, one that can accommodate various nonimplementation scenarios without necessarily abandoning the objective of inducing emitters to plan for future abatements (assuming that the scientific concerns are here to stay).

Alternatively, governments (including Canada's) may attempt to partially fulfill their Kyoto commitments without going through the more transparent but likely more contentious exercise of legislative ratification. The danger here is that this less transparent approach could lead to adopting an array of inferior, costly measures in the name of "doing something," without reference to an overall accountability framework.

I propose a policy framework that is sufficiently flexible to adapt to various scenarios and that is superior to having the issue addressed through a series of ad hoc measures.

Accordingly, I propose a policy framework that is sufficiently flexible to adapt to various scenarios regarding the implementation of Kyoto and that is superior, *vis-à-vis* Canada's economic and environmental interests, to having the issue addressed through a series of *ad hoc* measures.

A Tradable Permit/Credit System

The basis for Canada's national strategy should be the voluntary enrollment of emitters in a hybrid system of tradable emissions permits and credits.

The permits issued initially would correspond to current emissions, as reported by these emitters and independently audited. The permits would contain escalator provisions for the allowable emissions to increase if circumstances warranted (as described below).

Once Canada ratified the Kyoto Protocol (or a similar agreement in the future), the annual allowance covered by the permit would fall over time. This decline would be in line with Canada's reduction commitments in Kyoto and include an additional percentage corresponding to Canada's expected growth in net capital stock over the period. The latter provision would allow the issuance of some new permits every year; they would have to be attached to verifiably new capital projects. (Thus, new projects could come on stream over time without compromising Canada's overall emissions-reduction objectives.)

The members of the system would be able to bank permits to take into account, for example, temporary fluctuations in economic activity, emergencies, or waiting time before opportunities arise to reduce emissions when replacing existing capital stock. Indeed, one of the most important features of the system would be its flexibility, both before and after any legislated reductions.

Initially, the system would be quasi-experimental, not least because agreement on specific design features is unlikely without a tryout period.

Existing Emitters

In the event Canada ratifies any reduction commitments, the permits would allow emissions no less than proportional to those commitments.

Existing emitters who wished to participate in the system would identify themselves at the beginning as requiring permits. After this initial registration period, no new entrants would receive permits for existing emissions, a rule that would provide a major incentive to participate. It would be understood that, in the event Canada ratifies any reduction commitments, the permits would allow emissions no less than proportional to those commitments at the time.

Permits would cover the CO_2 equivalent of any gas targeted for reduction under the Kyoto Protocol. (For CO_2 alone, Haites [1998] estimates that 350 to 750 larger firms in Canada could be involved in a tradable permits scheme.)

Assuming that reaching the target implied reducing emissions by some 21 percent below those of a certain base year (say, between now and 2015), permits would be issued to any registered emitter, giving it the right to free GHG emissions up to the following amounts in subsequent years. Say the first (base) year was 2000. Then the permits would cover

	Emissions Allowed *(% of emissions in base year)*
Base year	100
2001–05	93 *less* $E(\dot{K})2001-05$
2006–10	86 *less* $(\dot{K}2001-05 + E(\dot{K})2006-10)$
2011–15	79 *less* $(\dot{K}2001-10 + E(\dot{K})2011-15)$,

where $\dot{K}$ represents the actual growth rate in Canada's net capital stock for the period indicated and $E(\dot{K})$ the expected growth rate in that stock for the five-year period indicated over the previous five-year period.

These amounts would represent the *minimum* level of free or low-cost emissions allowed existing emitters within the system. A permit owner could acquire additional permits in one of the following ways:

- purchase from other Canadian holders (whose permits would then be debited);
- purchase from owners of similar permits in other countries (provided this exchange is allowed by legislation in both countries); and
- GHG reductions made by the emitter in non–Annex I countries that the Canadian emitter has had recognized by the clean-development mechanism to be set up under Kyoto.

Furthermore, existing permit owners would be eligible for additional permits for new projects and for government-approved emissions top-ups, as detailed below.

New Projects

Any firm contemplating a startup or a net addition to its capital stock would be allowed to bid for a quantity of permits set aside by the government at a rate corresponding to the expected growth rate in the economy's net capital stock over the

base year. An alternative that may limit the amount of new project "leakage" to non–Annex I countries would be to allocate these permits on the basis of "best practice" estimates for similar investments elsewhere.

The idea would be to ensure that the "rents" accruing to existing emitters were progressively transferred to the government if emissions reductions indeed proceeded in Annex I countries, but that, in the meantime, the existence of these rents would not pose a barrier to initiating new projects.

Additional Permits

A key element of the system would be for the federal government to allow additional permits to be issued.

A key element of the system would be for the federal government to allow additional permits to be issued under two well-defined conditions. These permits would be indistinguishable from permits issued initially to existing emitters and to new projects sponsors (described above).

The conditions under which additional permits would be issued are:

- Other Annex I countries make little if any progress in controlling their own emissions. Canada would reserve the right periodically to top up existing emissions permits to bring its decline in emissions to no more than the average of that achieved in other Annex I countries. Each country's reduction would, for example, be weighed by the value of its trade flows with Canada.
- Other Annex I countries make permits available for government-to-government transactions but there is no open trade in them. (This situation would arise if permits could not be exchanged privately across national borders.) If the price — say, per tonne of emissions — of these permits were lower than the current market price of Canadian emissions permits, Ottawa would undertake to purchase them from the other governments and give all existing permit-holders the right to top up their permits for emissions in Canada, proportionately to the size of the international purchase, at the same price per tonne it paid to acquire them (plus its administrative costs).

Monitoring

As already noted, one of the theoretical drawbacks of a permit system is the fairly extensive monitoring it requires. In my view, Canada's current VCR program already has part of the infrastructure in place to undertake such monitoring, provided it is audited to the satisfaction of the federal government, which would ultimately have to vouch for the country's emissions abatement.

An Options and Futures Market

To supplement the permit-holders' spot market just described, Canada should encourage the emergence of an organized options and futures market for emissions permits. Such a market would encourage other agents to deal more efficiently with the climate change issue as it affects them, taking advantage of or protecting themselves against fluctuations in the price of the permits (the underlying asset). Furthermore, it

The federal government and the provinces should encourage the financial sector to establish an options and futures market for emissions permits.

could provide for those who need it a source both of financing emissions-reduction activities and of protecting against the effects of warming itself. Hence, the federal government and the provinces should encourage the financial sector to establish such a market in Canada. They could, if necessary, be active participants, giving signals to the marketplace of future policy intentions.

The derivatives market would be open to all. Potential purchasers of options and futures would include:

- Reinsurers worried about the impact of changing weather patterns on claims, which would rise with any evidence of harmful anthropogenic effects. At the limit, if such evidence was not forthcoming, the options and futures would be worthless, but this situation would also be reflected in positive bottom lines in terms of claims. (Foreign insurance companies could participate, thus enhancing liquidity.)
- Firms wishing to protect themselves against increases in the price of permits over the course of a project they are undertaking. Alternatively, they may judge it an unacceptable risk that not enough low-cost permits would be available under the new-projects program described above.

Conversely, the following players might issue securities in this market:

- Sponsors of large-scale hydroelectric or nuclear projects who were seeking financing. They would deliver the underlying security to the purchaser when their own projects came on stream.
- Firms or consortiums engaged in R&D or their backers, such as venture capital firms, seeking a means of financing their projects. Again, the value of a firm's R&D efforts toward emissions reduction (or at least of a portfolio of such firms) would go up or down more or less in line with the price of the option or futures contract. That is, if the warming problem came to be deemed not as serious as thought, the value of the options and futures contracts on which these companies must deliver would not be very high. On the other hand, if the problem was exacerbated, the value of futures and options would have increased, and so would the value of a successful R&D effort.

In general, all participants with a direct or indirect interest in the amount of GHG emissions allowed in Canada would find in such a market a chance to position themselves according to what they believe would be the ultimate emissions levels (a view that might differ from participant to participant). At the same time, it would ensure that all players collectively arranged their activities to move toward reducing emissions at least in line with those of Canada's major trading partners.

The Role of Emissions-Reduction Credits

No permit scheme would be able to capture all sources of GHG emissions in Canada. The challenge is to have a complementary scheme for these other sources, one that is compatible and integrated with the permit schemes for large sources and therefore ties into the international trading possibilities envisaged under the Kyoto Protocol.

In my view, the answer lies in issuing tradable emissions-reduction credits to any goods- or services-producing entity, public or private, profit or nonprofit, that manages

to effect and document a permanent reduction in emissions. The credits these entities received would be fully exchangeable on the permits market, obviously at the same price, so the cost of the marginal emission (the benefit of the marginal reduction) would be the same across large and small emitters in the economy. Emissions reductions would be voluntary, but they would be rewarded. And such reductions likely would occur where and when they were least costly for the economy.[26]

The credit could apply, for example, to municipalities that invested in the flaring or useful capture of methane gas at municipal dumps, to builders or even vehicle manufacturers that voluntarily exceeded existing codes and standards in such a way that their products were more emissions friendly, or to utilities that help their customers implement significant energy-saving projects.

This system would be particularly well-suited to encouraging the adoption of no-regrets energy-efficiency measures.

This system would be particularly well-suited to encouraging the adoption of no-regrets energy-efficiency measures, encouraging Canadians to make themselves aware of and implement them. Where there was a widespread take-up of a particular measure, governments or industries would have reasonable grounds to turn it into a new standard, setting a new threshold for obtaining credits in a subsequent period.

A complementary activity would be the establishment of an inventory of possible measures (whether for individuals, businesses, or public actors) that reported their engineering feasibility, likely impact on emissions, and cost and benefits of implementing them.

This system would respond to the market-failure argument in favor of adopting mandatory standards and would demonstrate whether reductions can really be achieved at reasonable cost.

Subsidies

Well-functioning markets for permits would help GHG reductions to occur in the most cost-effective way without government financial intervention. Markets may, however, work imperfectly. For example, the cost of gathering information on how to reduce emissions might be prohibitive for small emitters (builders, farmers, municipalities, and so on) and they might, therefore, not act to obtain emissions-reduction credits even if there would be financial gains in doing so. The government might, therefore, wish to subsidize the dissemination of information on various practices these smaller players are likely to adopt.

Likewise, government financial intervention should be limited to areas where market failure was anticipated, such as supporting R&D efforts if potential free-rider problems arose (for example, if no private backers could be found for basic technology that was promising yet costly), although the point of the permit/credit-trading system would be precisely to stimulate private efforts in this direction without the need for direct government intervention.

---

26 This credit aspect of my proposed strategy is similar to the voluntary credit-trading program that the National Roundtable on the Environment and the Economy (NRTEE) recommends as a "logical first step" toward a possible regulated domestic emissions-trading program, a recommendation based partly on the fact that two pilots for such programs are already in place in Canada (NRTEE 1999a, 10).

Climate Adaptation Policies

One area in which market failure seems likely is in implementing a whole range of climate adaptation measures. While all previously mentioned policies are chiefly concerned with mitigating human-induced climate change, adaptation policies are concerned with altering human activities in ways that reduce society's vulnerability to climate change (Burton 1998).

Adaptation is an important default option and should be part of Canada's strategy.

Because the likelihood and extent of climate change is uncertain, adaptation policies cannot play the major role in Canada's global warming strategy and certainly none toward the implementation of the Kyoto Protocol. Nevertheless, adaptation is an important default option and should be part of Canada's strategy, particularly as an escape hatch in the event other countries do not meet their emissions-reduction targets. (Remember that Canada's own emissions reductions will count for practically nothing if other countries, including developing countries eventually, do not also get their act together.)

Some may think that adaptive actions, by lowering the cost and riskiness for Canada of the anticipated warming, might diminish political support in Canada for reducing emissions. This outcome is, however, unlikely. The investments required for serious preparedness would just as likely alert Canadians to the significance of the issue. And, as a general proposition, such policies could prepare us for only some, not all, of the expected changes.[27]

In other words, to the extent that we believe in the danger caused by increasing GHG concentrations in the atmosphere, preparedness makes common sense in case of global failure to sufficiently reduce emissions.[28]

This *Commentary* is not the place to review the kinds of policies that would decrease Canada's vulnerability to climate change. But it is a good place to emphasize that publicly funded efforts to devise preparedness scenarios should be part of the overall strategy.

Summary: The Best Combination of Attributes

In short, Canada has excellent reasons to aim at first reaping the lower hanging fruits of the global warming challenge, whether these are available domestically or internationally. In addition, it is important that both domestic strategies (encompassing all sources) and the international strategies (earning and purchasing credits) aim at ensuring that these fruits be as plentiful as possible.

Implementation of the Strategy

Canada hopes to have a national implementation strategy later this year. In the fall, important strategic and tactical decisions must also be taken in international forums

---

27 Burton points out, "[T]he climate change that is now projected will be more rapid than any previously experienced in history and probably most of pre-history as well....While human systems can be adapted, even rapidly adapted if necessary, unmanaged forests, natural ecosystems and wildlife cannot adapt very quickly and hence are at risk. Perversely, insect pests and disease vectors can adapt by migrating quickly into new zones of climatic opportunity" (1998, 7–8).

28 Though it cannot replace the need to search for ways to reduce emissions themselves, partly because the projected climate change would be so rapid that not all systems can adapt even as well as humans.

toward implementation of the Kyoto Protocol. Clearly, the former will have to be consistent with the latter. Accordingly, I now turn to an examination of the future international implementation issues, followed by a consideration of domestic implementation issues.

For the international implementation of the Kyoto Protocol, at least two questions of great significance to Canada and other countries remain outstanding. The first is the sale and purchase of emissions credits. The second is the enforcement of the agreement (look back at Box 1).

As the post–Kyoto environment for reducing emissions is negotiated, Canadian policymakers should:

- Push for the clean-development mechanism to receive widespread use as soon as possible. It is a key element of flexibility for reducing emissions worldwide and domestically at low cost with equal benefit for the environment. It would also help clean technologies reach developing countries.
- Work to establish the convertibility of permits between countries, so private sector actors could begin trading among themselves.
- Explore with the United States the possibilities of joint implementation. Given that Canadian exports of energy, particularly natural gas and hydroelectricity, would contribute to the United States' meeting its Kyoto targets while making it more difficult for Canada to meet its own, Canadian delegates should make sure that future international negotiations on the relevant mechanisms will make such arrangements possible and practical when there is strong bilateral representation (from, for example, Canadian exporters and US users of energy) on both sides of a border.
- Work toward recognition of Canada's relatively fast rate of population growth. Although negotiators failed to win this point at Kyoto, they should try to reopen the issue by 2005, when countries will begin to consider targets for the post–Kyoto period.
- Vigorously promote the elimination of subsidies to the carbon-based energy sector. Such a move would be a relatively efficient global approach to meeting the Kyoto and post–Kyoto targets. Countries with the highest and most distorting subsidies should be first in line to eliminate them. Canadian negotiators should suggest the calculation of "producer-equivalent subsidies" to facilitate equitable comparisons between countries, as was done for agricultural subsidies in the 1980s before the Uruguay Round of the General Agreement on Tariffs and Trade.
- Refuse to leave the enforcement of the agreement on its territory to countries that are not themselves required to make reductions in their emissions. Furthermore, no country should be subject to sanctions of any kind unless a significant percentage of others have achieved their targets.
- Continue to try to involve developing countries in joining the emissions-reduction process through active policies.
- Promote the view that any assistance measure from Annex I countries should have priority availability to countries that have made significant commitments to change their incentive structures away from carbon-intensive development.

Canadian exports of energy, particularly natural gas and hydroelectricity, would contribute to the United States' meeting its Kyoto targets.

Meanwhile, implementation of Canada's own Kyoto strategy will require hard work on several fronts.

Federal-Provincial Cooperation

Following the Kyoto conference, Canada's first ministers agreed that, whatever means the country chose to reduce emissions, no region should be asked to carry an unreasonable burden from the effort (McCloskey 1998, 2).

There are questions here about how far Ottawa can go in implementing a strategy unilaterally. The federal government's ability to sign and implement international treaties is well established. Yet substantial consent from the provinces is, in practice, necessary in areas of their jurisdiction. Indeed, a process is being established to permit provincial and territorial governments to participate fully in implementing and managing the Protocol.

The permit/credit system discussed in this *Commentary* could allay provincial concerns regarding a carbon tax and competitiveness with the United States, especially if the provinces were allowed to earn credits for certain reduction measures (such as emissions by farms).

Subsidies and Other Budgetary Provisions

The federal government already spends considerable sums on climate change issues. The Energy Technology Branch and the Climate Change Action Fund were announced in the February 1998 federal budget. The fund, which has a budget of $150 million over three years, will "support the development of Canada's national implementation strategy....Such investments would target opportunities that have both high impact on emissions of greenhouse gases and high economic potential in domestic and international markets" (McCloskey 1998, 2).

If and as the market for emissions permits/credits gets into gear, there will be less need for public subsidies to R&D.

As already suggested, if and as the market for emissions permits/credits gets into gear, there will be less need for public subsidies to R&D and more funds can be spent on informing the public (including emitters) about the possibility of and rewards for action, as well as on preparing to adapt to climate change.

Market Incentives and Early Industry Action

Canadian governments have announced a Baseline Protection Initiative, whereby companies can register with the VCR those actions that result in "real, measurable, and verifiable" reductions leading to emissions reductions (National Climate Change Process 2000). The initiative ensures that companies taking early actions can count them toward any future programs that allocate reductions on the basis of what emissions were in 1990; participants can reconstruct their baseline emissions as they would have been that year if they had not taken any action.

This initiative is commendable in that it assures companies that a future compulsory reduction policy will recognize what they are doing voluntarily now; it thus removes a serious disincentive to act. Note also that this initiative would facilitate the eventual allocation of emissions permits under the scheme proposed here. Once participants buy into the permit system, however, they will, by definition, have earned their baseline protection as they will hold permits equivalent to their emissions in the base year.

Removal of Obstacles to Efficiency

National energy policies and regional ones (such as those governing internal trade in electricity) should be examined to make sure they do not impede the development of non-carbon-intensive forms of energy (hydroelectricity, nuclear) or fuel switching toward less carbon-intensive forms of energy.

Long-Term Political Support

As already noted, long-term political support is key to success in reducing GHG emissions. At the very least, Canadians remain entitled to a full public and parliamentary debate on the issue, before ratification of the Kyoto Protocol and again when a plan of action is presented, so that they are fully aware of the economic and equity issues surrounding this long-term commitment.

If this opportunity is denied, we can expect that political support for the agreement and the measures needed to implement it will grow shakier over time, as subsequent governments grapple with the consequences.

Conclusion

Canadians who care about both the global environment and their country's economic prospects have the right to expect that decisionmakers will act in such a way that the imperative of concern for the first will not unnecessarily harm the second.

The challenges of determining Canada's proper role are particularly formidable with respect to the issue of humankind's impact on the rising trend in global temperatures via the emissions of GHGs, the main source of which is the burning of carbon-based fuels. This is true regardless of where one stands on the continuing scientific debate about the extent of this impact.

While the evidence certainly suggests that risk-averse individuals should be concerned about reducing GHG emissions around the world, everyone agrees that Canada's acting alone could make only an infinitesimal impact on temperatures, even a century down the road. The solution must, therefore, be global. And solutions will require some significant structural changes — in technologies or consumption patterns or both — that, if they are not to be very costly to the economy, will likely require the significant investments involved to take place over a fairly long time, perhaps corresponding to that of a normal replacement cycle for various types of private and public fixed capital.

We do not yet know how the extent of the obligations Canada may have to undertake could affect its competitive situation and, therefore, employment prospects.

In that light, the Kyoto Protocol exemplifies how not to meet the challenge. Its reduction targets and timetable are arbitrary, and they are not based on an analysis of the ability of signatories to meet them. Moreover, the agreement does not adequately address the issue of less carbon-intensive growth in the developing countries, which will soon account for more than half of the world's emissions.

Little wonder, then, that the Protocol had not, at the time of writing, been ratified by any of the countries that pledged reductions. Hence, we do not yet know how the extent of the obligations Canada may have to undertake could affect its competitive situation and, therefore, employment prospects at home. This uncertainty calls for the federal government to adopt only policies that are responsive to external circumstances.

On the other hand, the Protocol also included some useful principles. The most notable is that of emissions-reduction credit trading, which would allow, up to a point, countries in which reductions would be very costly to purchase credits from countries that could more easily effect theirs. This mechanism could help reduce the cost to the global economy of a given worldwide reduction in GHGs, as could the ability, through a clean-development mechanism, of an Annex I country to count toward its own reduction target projects that reduce emissions in developing countries. Canada should develop policies that are compatible with these emerging international mechanisms.

Canada must prepare for the possibility that a significantly warmer world will arrive regardless of what it does.

Under the circumstances, what can Canada do? First, it must prepare for the possibility that a significantly warmer world will arrive regardless of what it does, a requirement that calls for sensible investments to help Canadians adapt to such a world. Any further solution must be a longer-term one and involve all other major countries. Canada can do its part by adopting a policy that encourages individuals, companies, and institutions to prepare intelligently for a more carbon-constrained world. Such a policy should go beyond the purely voluntary approach that has prevailed until now, but it should minimize reliance on the costly and unresponsive bureaucratic imposition of emissions reductions in specific areas.

On that basis, I recommend an initially voluntary and quasi-experimental hybrid system of tradable GHG-emissions permits and emissions-reduction credits. The permit system would require participating emitters to account for their emissions and remit corresponding permits to an independent authority.

Initially, participants (expected to be mainly large emitters) would receive permits corresponding to their current emissions levels. It would be understood, however, that, once Canada ratifies the Kyoto Protocol or (more likely) some amended reduction formula, the emissions allowed by these permits would fall over time, proportional to the country's overall commitments. Nevertheless, allowed emissions could also be topped up for new capital projects and by investments abroad that create real emissions reductions there, by the purchase of reduction credits from other countries, and also by the failure of Canada's trading partners to meet their own targets.

Any entity, participant in the permit system or not, could get recognition for emissions-reduction credits generated through projects that verifiably reduce GHG emissions somewhere. The independent body overseeing the permit system would include a committee of experts that would approve guidelines for credits to be issued for various types of reduction initiatives.

Anyone could earn credits, which would be inventoried and made to count toward Canada's emissions-reduction commitments. Credits should then be inter-changeable with permits — that is, permit-holders could purchase credits generated by emissions-reductions projects anywhere (including by non-permit-holders). Establishing a value for these credits on the permit market would encourage smaller emitters, such as municipalities, to contribute to emissions reductions.

To provide an incentive to participate in the permit system, Canadian governments should pledge to recognize the ability of permit-holders to continue emitting GHGs as their permits allowed (albeit at a declining rate) and to maintain the top-up provisions under any compulsory scheme.

The permit market could easily spawn a derivatives market that could both improve the financing of emissions-reduction projects and allow investors to protect

themselves against sharp rises in the price of permits — and even against adverse financial implications of global warming.

What would Canadians gain by having such a system in place? First, they would be assured that Canada would be well prepared in advance to do its part in reducing global GHG emissions once both it and its trading partners ratify emissions reductions. That is, this policy would be more effective than, for example, relying only on the hope that large investments in emissions-reduction technologies alone will do the trick.

Second, a tradable permit and credit system would ensure that emitters themselves commit, for their own benefit, to emissions-reducing investments where these make the least damage to incomes in the domestic economy or, indeed, globally. This system would therefore be more efficient than one in which a series of command-and-control measures mandated where and how reductions should proceed. Although government-imposed standards may have a place in the policy arsenal if it becomes necessary to impose emissions reductions on laggards, in most cases such a system is not likely to be the first-best option for large emitters. And relative to a carbon tax — another much-discussed policy option — a tradable permit and credit system would exhibit a number of desirable properties in terms of equity and political feasibility in a Canadian context, even though it may not be the first choice from the point of view of administrative ease.

In doing its part, Canada will be able to match the benefits of emissions abatement with its costs.

Finally, the flexibility built into the policy would help assure Canadians, when they finally get a chance to examine in public forums the actual consequences of the kind of commitment made in Kyoto, that, in doing its part, Canada will be able to match the benefits of emissions abatement with its costs.

References

Bradford, David B. 1997. "On the Use of Benefit-Cost Reasoning in Choosing Policy toward Global Climate Change." NBER Working Paper 5920. Cambridge, Mass.: National Bureau of Economic Research.

Burton, Ian. 1998. "Climate Adaptation Policies for Canada?" *Policy Options* 19 (4): 6–10.

Canada. 1992. *Economic Instruments for Environmental Protection*. Canada's Green Plan. Ottawa.

———. 1998. Technical Committee on Business Taxation. *Report*. Ottawa: Department of Finance.

———. 1999a. *Canada's Emissions Outlook: An Update*. Ottawa: National Climate Change Process — Analysis and Modelling Group.

———. 1999b. *Canada's Greenhouse Gas Inventory: 1997 Emissions and Removals with Trends*. Ottawa: Environment Canada.

Canadian Council of Ministers of the Environment (CCME). 1996. *A Fresh Look at Economic Instruments, Final Report*. Prepared for the CCME by the Pembina Institute for Appropriate Development, with Apogee Research International Ltd. Winnipeg: Canadian Council of Ministers of the Environment.

Cooper, Richard N. 1998. "Toward a Real Global Warming Treaty." *Foreign Affairs* 77 (2): 66–79.

Council of the European Union. 1998. "Community Strategy on Climate Change — Council Conclusions." Press Release Information Document 09402/98 (Presse 205). Luxembourg.

Cramton, Peter, and Suzi Kerr. 1999. *Tradeable Carbon Permit Auctions: How and Why to Auction not Grandfather*. College Park, Md.: University of Maryland, Department of Economics.

Deangelo, Benjamin, and L.D. Danny Harvey. 1998. "The Jurisdictional Framework for Municipal Action to Reduce Greenhouse Gas Emissions: Case Studies from Canada, the USA and Germany." *Local Environment* 3 (2): 111–136.

Dougher, Rayola S., and Russell O. Jones. 1998. *Implications of the Kyoto Protocol Targets for OECD Countries*. Research Study 093. Washington, DC: American Petroleum Institute.

Haites, Erik. 1997. "Briefing Document on Emissions Trading for Greenhouse Gases." Prepared for the National Round Table on the Environment and the Economy.

———. 1998. "Emissions Trading for Greenhouse Gases in Canada." *Policy Options* 19 (4): 20–24.

———, and Brian Jantzi. 1996. "Emissions Trading for Greenhouse Gases." Mimeographed.

Hamilton, Kirk, and Grant Cameron. 1994. "Simulating the Distributional Effects of a Canadian Carbon Tax." *Canadian Public Policy* 20 (4): 385–399.

Harvey, L.D. Danny. 1995. "Creating a Global Warming Implementation Regime." *Global Environmental Change* 5 (5): 415–432.

———. 1996. "Development of a Risk-Hedging CO_2-Emission Policy." *Climatic Change* 34: 1–71.

———, Ralph Torrie, and Robin Skinner. 1997. "Achieving Ecologically-Motivated Reductions of Canadian CO_2 Emissions." *Energy* 22 (7): 705–724.

Hornung, Robert. 1998a. "The Voluntary Challenge Program Will Not Work." *Policy Options* 19 (4): 10–13.

———. 1998b. "ENGO Views on Emissions Trading in Canada." Presented at the 1998 CERI (Canadian Energy Research Institute) Climate Change Conference, Calgary, May 4–5.

———, and Matthew Bramley. 2000. *Five Years of Failure: Federal and Provincial Government Inaction on Climate Change during a Period of Rising Industrial Emissions*. Ottawa: Pembina Institute for Appropriate Development.

Howatson, Al, and Jan Campfens, 1997. *The Economic Impact on Canada of Greenhouse Gas Reductions: A Comparative Review*. Ottawa: Conference Board of Canada, Business and the Environment Research Program.

Intergovernmental Panel on Climate Change (IPCC). 1995. *IPCC Second Assessment Synthesis of Scientific-Technical Information Relevant to Interpreting Article 2 of the UN Framework Convention on Climate Change*. Geneva: IPCC.

Jonas, Matthias, et al. 1999. *Full Carbon Accounting and the Kyoto Protocol: A Systems- Analytical View*. Interim Report IR-99-025. Laxenburg, Austria: International Institute for Applied Systems Analysis.

Kaya, Y. 1990. "Impact of Carbon Dioxide Emission Control on GNP Growth: Interpretation of Proposed Scenarios." Paper presented to the Intergovernmental Panel on Climate Change Energy and Industry Subgroup, Response Strategies Working Group, Paris.

Keller, Klaus, et al. 1999. "Preserving the Ocean Circulation: Implications for Climate Policy." CES Working Paper Series 199. Munich: Center for Economic Studies and Ifo Institute. October.

Lightfoot, H. Douglas, and Chris Green. 1998. "New Sources of Energy Are Needed to Halt Global Warming." *Policy Options* 19 (4): 6–10.

McCloskey, Jean. 1998. Notes for a speech by the Deputy Minister of Natural Resources to the Canadian Energy Research Institute. Calgary, May 4.

McKibbin, Warwick J., and Peter Wilcoxen. 1997. *A Better Way to Slow Climate Change*. Brookings Policy Brief 17. Washington, DC: Brookings Institution.

———, and Peter Wilcoxen. 1999. "Permit Trading under the Kyoto Protocol and Beyond." Paper prepared for a workshop of the Energy Modeling Forum/International Energy Agency (IEA)/International Energy Workshop held at the IEA, Paris, June 16–18.

McKitrick, Ross. 1997. "Double Dividend Environmental Taxation and Canadian Carbon Emissions Control." *Canadian Public Policy* 23 (4): 417–434.

Michaelis, Laurie. 1997. "Reforming Coal and Electricity Subsidies." Annex I Expert Group on the UN FCCC, Policies and Measures for Common Action Working Paper 2. Paris: Organisation for Economic Co-operation and Development.

Michaels, Patrick J. 1998. *The Consequences of Kyoto*. Cato Policy Analysis 307. Washington, DC: Cato Institute.

Muller, R. Andrew, and Stuart Mestleman. 1998. "What Have We Learned from Emissions Trading Experiments?" *Managerial and Decision Economics* 19 (4–5): 225–38.

National Climate Change Process. 2000. "Federal, Provincial and Territorial Governments Announce a Climate Change Baseline Protection Initiative." Media Advisory and Backgrounder. Ottawa: National Climate Change Secretariat. January 12.

National Round Table on the Environment and the Economy (NRTEE). 1999a. *Canada's Options for a Domestic Greenhouse Gas Emissions Trading Program*. Ottawa: NRTEE.

———. 1999b. "Potential of Including Non-Combustion Sources of GHG Emissions in a Domestic Emissions Trading Program." Domestic Greenhouse Gas Emissions Trading Technical Paper Series. Ottawa: NRTEE.

Nordhaus, William D. 1998. "Assessing the Economics of Climate Change: An Introduction." In William D. Nordhaus, ed., *Economic and Policy Issues in Climate Change*. Washington, DC: Resources for the Future Press.

Organisation for Economic Co-operation and Development (OECD). 1998. "Chapter VII: The Economics of Climate Change." *OECD Economic Outlook* 63 (June): 193–203.

Parry, Ian W.H., Roberton C. Williams III, and Lawrence Goulder. 1997. "When Can Carbon Abatement Policies Increase Welfare? The Fundamental Role of Distorted Factor Markets." NBER Working Paper 5967. Cambridge, Mass.: National Bureau of Economic Research.

Parry, Martin, and Timothy Carter. 1998. *Climate Impact and Adaptation: A Guide to the IPCC Approach*. London: Earthscan Publications Limited.

Peck, S., and T. Teisberg. 1994. "Optimal Carbon Emission Trajectories when Damages Depend on the Rate or Level of Global Warming." *Climatic Change* 28: 289–314.

Pembina Institute for Appropriate Development and David Suzuki Foundation. 2000. *Fuel Cells: A Green Solution?* Drayton Valley, Alta.; Vancouver: Pembina Institute for Appropriate Development and David Suzuki Foundation.

Peterson, T.C., et al. 1999. "Global Rural Temperature Trends." *Geophysical Research Letters* 26 (3): 329–332.

Rhéaume, Gilles. 1993. *The Challenge of Climate Change: Policy Options for Canada*. Report 112-93. Ottawa: Conference Board of Canada.

Schelling, Thomas C. 1997. "The Cost of Combating Global Warming: Facing the Tradeoffs." *Foreign Affairs* 76 (November/December): 8–14.

Schmalensee, Richard, et al. 1998. "An Interim Evaluation of Sulfur Dioxide Emissions Trading." *Journal of Economic Perspectives* 12 (3): 53–58.

Schwanen, Daniel. 1997. "Confronting the Greenhouse Challenge: Matching Protection with Risk." *C.D. Howe Institute Commentary* 99. October.

Schwartz, Daniel. 1997. "The Emission-Based Vehicle Charges: A Market-Based Solution to Canada's Automobile Pollution Problem." *Fraser Forum*, July, pp. 41–42.

Shackleton, R., et al. 1992. "The Efficiency Value of Carbon Tax Revenues." Working Paper 12.8. Presented at the Energy Modeling Forum Working Group Meeting, Stanford, Cal., February 26–28. Mimeographed.

United Nations. 1997. *Kyoto Protocol to the United Nations Framework Convention on Climate Change*. Framework Convention on Climate Change Conference of the Parties, Third sessions, Kyoto, December 1–10, Agenda Item 5, FCCC/CP/1997/L.7/Add.1. Retrieved from Internet website: www.unfccc.de/resource/convkp.html.

Walton, Dawn. 2000. "Ballard powers ahead with fuel cell." *Globe and Mail* (Toronto), January 10, p. B1.

Wigley, T.M.L., R. Richels, and J.A. Edmonds. 1996. "Economic and Environmental Choices in the Stabilization of Atmospheric CO_2 Concentrations." *Nature* 379 (January 18): 240–243.

World Energy Council and International Institute for Applied Systems Analysis (IIASA). 1995. *Global Perspectives to 2050 and Beyond: 1995 Report*. London: World Energy Council.

C.D. Howe Institute Publications of Related Interest

Oct. 1997 — Schwanen, Daniel. "Confronting the Greenhouse Challenge: Matching Protection with Risk." *C.D. Howe Institute Commentary* 99. 36 pp.; $6.00; ISBN 0-88806-419-5.

1994 — Benidickson, Jamie, G. Bruce Doern, and Nancy Olewiler. *Getting the Green Light: Environmental Regulation and Investment in Canada*. Policy Study 22. 160 pp.; $14.95; ISBN 0-88806-348-2.

1993 — Doern, G. Bruce. *Green Diplomacy: How Environmental Policy Decisions Are Made*. Policy Study 16. 114 pp.; $14.95; ISBN 0-88806-310-5.

1990 — Doern, G. Bruce (ed.). *Getting It Green: Case Studies in Canadian Environmental Regulation*. Policy Study 12. 214 pp.; $14.95; ISBN 0-88806-269-9.

Recent Issues of *C.D. Howe Institute Commentary*

No. 140, April 2000 — Schwanen, Daniel. "Putting the Brain Drain in Context: Canada and the Global Competition for Scientists and Engineers." 20 pp.; $10.00; ISBN 0-88806-466-7.

No. 139, April 2000 — Ryan, Claude. "Consequences of the Quebec *Secession Reference*: The Clarity Bill and Beyond." 32 pp.; $10.00; ISBN 0-88806-472-1

No. 138, March 2000 — Popov, Vladimir. "The Currency Crisis in Russia in a Wider Context." 26 pp.; $10.00; ISBN 0-88806-465-9.

No. 137, February 2000 — Mintz, Jack M., and Thomas A. Wilson. "Capitalizing on Cuts to Capital Gains Taxes." 27 pp.; $10.00; ISBN 0-88806-470-5.

No. 136, February 2000 — Poschmann, Finn, and John Richards. "How to Lower Taxes and Improve Social Policy: A Case of Having Your Cake and Eating It Too." 18 pp.; $10.00; ISBN 0-88806-468-3.

No. 135, February 2000 — Monahan, Patrick. "Doing the Rules: An Assessment of the Federal *Clarity Act* in Light of the *Quebec Secession Reference*." 39 pp.; $10.00; ISBN 0-88806-467-5.

No. 134, February 2000 — Robson, William B.P., Jack M. Mintz, and Finn Poschmann. "Budgeting for Growth: Promoting Prosperity with Smart Fiscal Policy." 35 pp.; $10.00; ISBN 0-88806-469-1.

The C.D. Howe Institute

The C.D. Howe Institute is an independent, nonprofit, research and educational institution. Its goals are to identify current and emerging economic and social policy issues facing Canadians; to analyze options for public and private sector responses; to recommend, where appropriate, particular policy options that, in the Institute's view, best serve the national interest; and to communicate the conclusions of its research to a domestic and international audience in a clear, nonpartisan way. While its focus is national and international, the Institute recognizes that each of Canada's regions may have a particular perspective on policy issues and different concepts of what should be national priorities.

The Institute was created in 1973 by a merger of the Private Planning Association of Canada (PPAC) and the C.D. Howe Memorial Foundation. The PPAC, formed in 1958 by business and labor leaders, undertook research and educational activities on economic policy issues. The Foundation was created in 1961 to memorialize the late Rt. Hon. Clarence Decatur Howe, who served Canada as Minister of Trade and Commerce, among other elected capacities, between 1935 and 1957. The Foundation became a separate entity in 1981.

The Institute encourages participation in and support of its activities from business, organized labor, associations, the professions, and interested individuals. For further information, please contact the Institute's Membership Coordinator.

The Chairman of the Institute is Kent Jespersen; Jack M. Mintz is President and Chief Executive Officer.